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EDUCATION AND THE UNIVERSITIES

LOOKING back over the programme of the meeting at Bristol of the British Association, the prominence of educational issues is noteworthy. They were specifically mentioned by Sir Robert Robinson in his presidential address, they were implicit in Prof. H. D. F. Kitto's evening discourse, and also in the presidential addresses of Mr. W. B. Mercer to Section M (Agriculture) and of Mr. Ritchie Calder to the Assembly of Corresponding Societies, and there were discussions on the training of the physicist and the teaching of chemical principles in school and university in which the appropriate section joined forces with Section L (Education). Of the discussions in the Education Section itself, that on "Man and his Machines", like the presidential address of Mr. J. F. Wolfenden and also Dr. J. Bronowski's address "The Educated Man in 1984" at the final session on September 7, were related also to this theme.

Broadly speaking, two main groups of issues were raised. The first relates to the training of the scientist himself, and the supply of trained scientists and technicians in sufficient numbers to meet the changing needs of society. The second relates to the interpretation of science and involves the general education of the scientist and the education of the community as a whole, so that it is competent to appreciate the scientific aspects of a problem when they are reasonably interpreted in non-technical language. The two sets of issues are interrelated, as was well shown in both Mr. Wolfenden's address and by Dr. Bronowski, as well as in the discussion on "Man and his Machines". Sir Ben Lockspeiser was emphatic that many more scientists and technologists are required than are available, as well as many more teachers of mathematics and science in the schools to supply them, and strongly disagreed with Dr. J. E. Richardson's view that no large increase in the number of technicians will be required by automation.

Although, however, we may succeed in attracting into careers in science and technology a sufficient number of those at present leaving school too early in order to enter on other careers, without detriment to the nation's proper requirements elsewhere, it would still appear that the balance between technologist or scientist and technician requires further investigation. It is likely to vary widely in different industries. Dr. J. E. Richardson's estimate could be reasonably correct for the electrical industry but wide of the mark elsewhere. Without, however, some rough idea of the quantitative demand, it is impossible to plan the expansion of technical or of technological education soundly.

At Bristol the qualitative issues, in the main, were discussed. It is true that if the quality of technical education and technological education in Britain is high, problems of adjustment to changes in demand for one category or another will be less acute, and all the more so if due attention is given to human aspects and to those liberal studies which were emphasized by Mr. H. A. Rée and in the recent report "Liberal Education in a Technical Age". None the less, the quantitative aspect requires greater attention than it has yet received, even in respect of university education. To read again in the light of to-day such an address as Mr. H. T. (now Sir Henry) Tizard gave to the Education Section of the British Association twenty years ago—with its reasoned argument that the universities were then too full, that we should concentrate not on increasing the number of university-trained scientists but on raising the standard, and aim at producing chiefly the leaders of the profession—is to be brought face to face with the questions: What is the real purpose of a university education in science, in technology or in any other faculty? And what are the real functions of the university in relation to the training of educated men and women or of the formation of informed opinion in society as a whole? How best and in what ways should a university serve society in the present times?

Sir Henry urged that it should be the function of a university school of engineering to send out from the university resourceful men whose education and outlook would enable them to attack with confidence the new problems perpetually arising in their chosen field. He urged also that science well taught could supply all that is best in the classical tradition, imparting accuracy and exactness and a discipline in clear thinking; that it could brace with its difficulties minds that are not afraid of obstacles and inspire with its beauty minds not insensitive to beauty. To-day, we find Sir Charles Morris, in his Joseph Payne Memorial Lectures at the College of Preceptors on the idea of university education, emphasizing that the primary educational duty of the university is to develop the power and habit of disciplined thinking and encourage the capacity to form good judgments. The most fundamental aim in education, he urges, is the development of the power of good judgment in answering the questions which cannot be answered by science but which must be answered in life—problems which no intensification of scientific training by itself will solve. Unless, however, the student acquires in his undergraduate years not only scientific understanding and skill in scientific method but also learns to practise and develop the powers of non-scientific judgment and decision, the university has failed in its task of producing an educated man or woman. On the other hand, in the measure in which it has developed that capacity and habit, it has largely solved the problem of education for citizenship.

Dr. Eric James put the issue in very much the same terms in his Science and Citizenship Lecture to the Science Masters' Association at King's College,

Newcastle upon Tyne, when he argued that the education that produces scientists must be broadened and strengthened in such a way—at any rate for the best of them—as to supply the opportunity that the best arts courses provide of discussing the general questions of social organization and human conduct. If the problems of our present civilization are to be solved, we must produce men of science not only in greater numbers and of great technical skill, but also able and determined to take their place as responsible citizens. They must, he continued, understand the dangers and the opportunities that are provided by the discoveries they themselves are making, and be prepared and equipped to lead mankind to resist the temptations of purely material triumphs and to use science, not as a means of enslavement, but as a force for the liberation and enrichment of the human spirit.

The essence of Dr. Bronowski's lecture to the Education Section at the Bristol meeting of the British Association was that this, though good in itself, is not enough. We would still in the next generation create a slave world unless we make certain that science is a part of the cultural education of all, and that the language of science is understood by the ordinary citizen. It is in this sense that we have to make science a part of our culture, and to ensure that the ordinary citizen has the capacity to see through any kind of nonsense, scientific as well as political, economic or social, and recognize a duty to resist and expose such nonsense.

In large measure that capacity is a condition of the effective functioning of a democracy, as was indeed recognized by de Tocqueville more than a century ago; nor can it be contended that we have gone far towards achieving that objective. Pragmatic educational objectives have indeed been concerned much more with the acquirement of professional or technical skills than with the stability of the whole system, upon which in the end the economic and social and political order really depend. When the Duke of Edinburgh, in his opening address to the Conference of Vice-Chancellors and Rectors of more than a hundred European universities at Cambridge last July, spoke of the great responsibilities of the universities of Western Europe to-day, he emphasized that this task of turning out pupils capable of recognizing and resisting unsound views belongs primarily to the universities rather than to the general educational system.

That in some degree is inevitable, but it can only safely be conceded if the universities interpret their detachment and independence as involving some responsibility for independent criticism and outspoken comment on issues of the day when the people are being misled in matters of fact. For such guidance to be given effectively, there must be some considerable measure of public understanding of the work and purpose of a university, and thus it comes about that the universities can only fulfil their responsibilities to-day if that public understanding exists, just as in Britain their increasing dependence on public funds makes public understanding the final safeguard of their freedom. The very extent to which the British Association meeting focused attention upon the education of the scientist and the education of the public in science suggests that the Association and its members are aware of the needs of to-day; for the recent meeting has at least clarified some of the issues which must be widely understood if the necessary changes in policy are to be made within or without the universities.

The discussions at the British Association meeting received the wider publicity; those at the universities conference, as would be expected, attracted much less attention but went deeper. Moreover, the Conference in itself directed attention to a further function of the universities which Prof. A. Haddow mentions in his contribution to "The Bomb: Challenge and Answer". Scientists, says Prof. Haddow, are troubled by doubts as to whether the universities are using their resources most constructively in discharging their responsibilities not so much to their countries as to the world. This is, of course, in contradiction to the view expressed by the Inter-University Council for Higher Education Overseas, which in reviewing recently developments between 1946 and 1954 commented that these developments had appeared in a period in which the prestige of universities has never been higher, and in which they have been exceptionally responsive to their national and international responsibilities.

It was perhaps fitting that Prof. Haddow should give expression to any legitimate doubts on this matter in that particular connexion, for no society or institution can bring men closer together than a university; and the contribution which universities could make in promoting international understanding, while it should not be overstressed, is indispensable. It should not be forgotten, however, that though response to the suggestion which Mr. Robert Birley made six years ago in his Reith Lectures has been disappointing, and perhaps the universities might have made more determined and constructive efforts to fashion a common culture in Europe, the hindrances to the interchange and migration of scholars and students are not of their making. If progress in the task of restoring some of the old international relations between universities and giving them a new significance, broader and more humane, than before, so that each nation is assisted to make its own special contribution to the common stock and absorbs much in return without losing its individual characteristics, the fault has lain rather with governments. The Conference at Cambridge demonstrated that universities are alive to the great importance of encouraging university study abroad in promoting the free exchange of ideas, and Sir Edward Appleton asserted that a university's function is pre-eminently to discover, or perhaps uncover, the spiritual and intellectual needs of society.

The Cambridge Conference at least encourages the hope that the universities will draw closer together not only in support of the free communication of knowledge by interchange of staff and students and by discussion and publication, but also in serving this function. In doing so, however, the universities must be no less careful to maintain their own academic

standards of sound learning and scholarship than has been the Inter-University Council for Overseas Education in watching over the development of the Colonial universities and university colleges. Extra-mural activities must not be pursued in a way or on a scale that leads to the lowering of standards; and this needs to be remembered in considering the universities' contribution to adult education at any level, and in assessing the demands on the universities for particular courses and perhaps especially courses in general education.

Here again Sir Henry Tizard said some wise words in the address already mentioned, and they are as pertinent to-day as when they were uttered. If university authorities complain that students are lacking in general education, it is for them, he urged, to do their best, by altering the conditions of entry or the standard of scholarships, to help schoolmasters to remedy the defects. "If it is really the general view that the school education of a student of science is too narrow, then the best practical step is to reform the University Matriculation examination, and make it appropriate to the normal age of entry. . . . If it is not considered worth while, the criticism of the general education of the science student loses most of its point."

These observations are worth recalling in considering the report on university entrance requirements which has recently come from a sub-committee of the Committee of Vice-Chancellors and Principals of the Universities of the United Kingdom, if only as a reminder of the wide background in which such decisions should be taken. They do not affect simply the training to be given to the university student, or the maintenance of university standards. They affect equally the character of secondary education as a whole, even the outlook and attitudes which determine whether or not a student turns towards a career in science or technology. Indirectly, they bear closely on the promotion of public understanding of the work of the universities as well as of the scientist and, if not the way in which the universities must carry out their educational work, very largely the character and extent of that work as a whole. If indeed we ceased to allow sectional views to influence decisions which should be taken primarily in regard to the educational needs and policy of the country as a whole, it might well be found that an appropriate solution of the problems of university selection and of university entrance requirements might so react on the work of the schools and of adult education generally that the demands on the universities for extra-mural work were considerably eased and much more readily confined to those of appropriate academic character. It can at least be said that, without imagination and insight, without more readiness to experiment than has frequently characterized the relations between school and university during the past twenty years, it will be difficult indeed for the universities either to fulfil their full responsibilities to the community, or to ensure the public understanding and support which will safeguard the freedom and trust in which their work is most fruitfully done.

LITERATURE OF THE SCIENCE OF THE PAST

Scientific Books, Libraries and Collectors

A Study of Bibliography and the Book Trade in Relation to Science. By John L. Thornton and R. I. J. Tully. Pp. x+288+12 plates. (London: Library Association, 1954.) 24*s*.

IT is an ambitious task that the authors of this book have undertaken, to give within 270 pages a well-documented citation of all the chief books in all branches of science from before the days of printing up to the end of the nineteenth century, supplemented by brief accounts of relevant bibliographic matters, such as the growth of scientific periodical literature (illustrated, incidentally, by a reproduction of the title-page of the first volume of *Nature*) and scientific publishing and bookselling. It is pleasant to be able to say that, considering the manifold difficulties, they have succeeded admirably. Where the more important authors are in question, a very short indication of what they accomplished is given, as well as the title, date and place of publication of their chief works; and even the lesser ones are given a few biographical lines. For those who want fuller information, the footnotes and the bibliography at the end give ample guidance as to whither to turn. This bibliography cites some 450 names, many with more than one publication to their credit, and this alone bespeaks long and expert work.

The first chapter, "Scientific Literature before the Invention of Printing", deals with authors, such as the Greeks and Alexandrians, writing in that period, but is chiefly concerned with printed editions of their works. Among the many odd facts that can be gathered in the next chapter, on "Scientific Incunabula", is that, whereas Italy has, according to one list, 1,445 such books to her credit and Germany not many less, England claims 23 only: the figures for incunabula of all kinds in the British Museum give England about a tenth the number set down to Italy. Apparently science was relatively unpopular with our early printers.

The seventeenth century, although not easy, was, perhaps, the simplest task. A grave omission is Guericke, and certain other German writers, such as Schott, might have been mentioned. Papin is another outstanding figure who is absent, as is Savery. The eighteenth century, with increasing publication, obviously demands careful selection: on the whole, the choice is very well made, but static electricity fares rather badly, both in authors and in the fact that one of the chief bibliographies is not cited. McKie's important work on the chemistry of the century is duly acknowledged. With the nineteenth century, the growth of scientific literature becomes, as the authors say, overwhelming. Much is done by citing bibliographies and other works, such as, in chemistry, those of Partington, to help the student without overloading the book. Anyone versed in the subject will note the absence of well-known names, especially in mathematics—Cantor's "Geschichte der Mathematik" is not mentioned—but clearly there is not room for everybody, even every distinguished body. When it is considered that all sciences, including, for example, conchology, are represented, it must be readily admitted that the authors have done well. The final chapter on "Scien-

tific Libraries of To-day" is a valuable guide to the libraries of Great Britain.

This learned and laborious work will be of great use both to librarians and to students of the history of science. When a new edition is called for, no doubt certain omissions, including those to which passing reference has been made and others that have been noted, will be remedied. A citation of English translations, where they exist, of works in foreign tongues might be well. A desirable addition would be a list of the Latin names given to cities in Latin editions of the seventeenth and eighteenth centuries. There are frequent references in this book to editions at "Geneva and also Coloniae Allobrogorum", but Geneva and Colonia Allobrogorum are the same place. It is pleasant to be able to end this notice not with the reviewer's customary complaint of an inadequate index, but with grateful acknowledgment of a full and excellent one, which adds to the value of the book.

E. N. DA C. ANDRADE

A REFERENCE WORK OF HYDRAULIC ENGINEERING

Irrigation and Hydraulic Design

By Dr. Serge Leliavsky. Vol. 1: General Principles of Hydraulic Design. Pp. xiii+492+13 plates. (London: Chapman and Hall, Ltd., 1955.) 126s. net.

THIS book is the first of three volumes dealing with the problems of irrigation engineering, and sets out the basic principles of design founded on the author's considerable experience of irrigation and hydroelectric systems of the Dnieper and Nile. The book is intended as a work of reference, and its length and the historical treatment adhered to throughout certainly preclude its use as a handbook.

The book is divided into three chapters. The first treats problems of flow through a pervious soil, as they affect the design of hydraulic structures. Starting from the basic concepts of flow in a homogeneous, porous medium, the author passes to discussions of uplift pressures, potential flow and the analytical methods of computing flow nets and base pressures for various foundation arrangements. This section, which is treated most exhaustively, is followed by a treatment of graphical and experimental methods for determining the flow net, approximate calculation by the method of independent variables, percolation in non-homogeneous soils, piping and finally percolation through earth embankments. In view of the limitation of the analytical methods to foundations, in which the geometry is fairly simple, more space might with advantage have been devoted to the more general, if less precise, methods.

The arrangement of the discussion of the theories of piping and uplift pressure is rather confusing. The Bligh creep-head theory is presented together with the earlier Terzaghi liquefaction theory, while Lane's weighted creep theory is reserved for a later section. Although he states that Lane's theory is but an extension of the earlier Bligh theory, the author fails to warn the reader of the dangers of their application to design. Modern practice in soil mechanics only admits the application of empirical design procedures when a more rational scientific approach is not available. Methods based on average soil coefficients must always be treated with suspicion. Also, the general problem of stability of weirs and failure due to shearing of the subsoil under conditions of upward seepage has unfortunately not been touched; neither has the potential instability at the toe due to vibration of the apron.

The second chapter deals with design methods for preventing or reducing scour downstream of hydraulic works. Early designs relied largely on a protecting apron downstream, and formulæ for the extent of the apron and the depth of scour to be expected were produced by Bligh and Khosla from an examination of existing weirs in India. The author shows that data for the depth of scour downstream of several barrages on the Nile confirm Khosla's findings, despite the approximate nature of the coefficients used. Later designs have been based almost exclusively on tests made with small-scale models, and a discussion of the underlying principles and the results occupies a large part of the chapter. As far as the motion of the water is concerned, the guiding principle of such tests is the conservation of the Froude number; but the parameter which controls the movement of bed material, and so is of paramount importance when relating scour in model and full scale, has not yet been settled. The author mentions the conflicting views of various authorities on the subject, without coming to any definite conclusion.

Apart from this question, models have been useful in revealing the flow patterns likely to occur in specific designs and have contributed largely to an understanding of the methods by which the standing wave can be used to reduce scour. One of the latest developments of this work referred to in the chapter is the production of a set of rules for the design of stilling basins to dissipate energy behind the wave in as short a distance as possible.

The last chapter consists of two sections. The first deals with uniform flow and traces the historical development of the subject from the early ideas of Galileo to the modern advances of Prandtl and his collaborators. The latter have succeeded in placing the subject on a rational basis, and the forms of the friction formulæ so deduced are rapidly supplanting the earlier purely empirical formulæ of Bazin, Ganguillet-Kutter and Manning. The second section is taken up with steady non-uniform flow and gives in considerable detail the various methods which have been used for integrating the basic flow equations, together with complete numerical tables and charts for their application.

The book is well illustrated and lucidly written and includes a good supply of references.

ASPECTS OF THE ANIMAL CELL

International Review of Cytology

Vol. 3. Edited by G. H. Bourne and J. F. Danielli. Pp. x+530. (London: Academic Books, Ltd.; New York: Academic Press, Inc., 1954.) 9.50 dollars; 76s.

THE thirteen articles which make up the third "International Review of Cytology" have in common a concern with some aspect or other of contemporary cell biology, the technical quality of their production, and the price one must pay to possess one or more of them. The first needs no comment, the second is good, and the third, by present-day standards, is not excessive. For the rest, each article should, but in a short space cannot, be treated separately on its merits. It would not be

right, even were the reproach just, to complain of a lack of balance in the choice of articles in what is only one volume of a continuing series. In fact, however, the editors have ranged widely over the field of animal cytology, and one's only fear is that the plant cell, which had a foothold in the first two volumes, has been deliberately excluded and not simply temporarily overlooked.

In no other field of biology does the worker lean so heavily upon his techniques or have to use such care in assessing their reliability. Hence most of these articles are to some extent critical surveys of the technical procedures relevant to their problems, and three of them (Chr. de Duve and J. Berthet, on differential centrifugation in the study of tissue enzymes; A. G. Everson Pearse, on azo dye methods in enzyme histochemistry; Roy G. Williams, on transparent chamber methods for work on living mammals) have the results of particular techniques as their main theme. Three others take a particular tissue element (G. Asboe-Hansen, the mast cell; E. W. Dempsey and A. I. Lansing, the elastic tissue; S.-O. Brattgard and H. Hyden, the nerve cell) and survey the knowledge of its composition, structure and function revealed by classical and by recent methods of research.

The behaviour of living cells or of cell populations is treated by Charity Waymouth in a review of the nutritional requirements of cells in culture, by T. Gustafson in a survey of enzymatic aspects of embryonic differentiation, and by I. Cornman in a brief discussion of the action of urethane on mitotic division. The nucleus alone is the hero of the remaining four articles. O. Bucher reports the measurements, made in his laboratory, of nuclear and nucleolar size of cells in tissue culture, M. Alfert discusses the structure and composition of giant chromosomes, and R. A. Beatty variations in chromosome numbers in mammalian somatic cells. Finally, A. L. Dounce presents a critical survey of recent studies of the enzyme content of cell nuclei isolated by chemical means.

The reviewer of Vol. 1 pleaded for titles of papers to be given in the lists of references. If a reminder will strengthen the editors' hands in forcing this reform upon unwilling authors, it is gladly given.

D. R. Newth

ADMINISTRATIVE CLASS OF THE CIVIL SERVICE

Higher Civil Servants in Britain from 1870 to the Present Day

By R. K. Kelsall. (International Library of Sociology and Social Reconstruction.) Pp. xvi+233. (London: Routledge and Kegan Paul, Ltd., 1955.) 25*s*. net.

THE scope and nature of this book are better indicated by the title of the article in the October–December, 1954, number of the *Political Quarterly*, in which Mr. R. K. Kelsall discussed the data obtained in a study of the social origins of members of the administrative class of the Civil Service above the rank of assistant secretary in three selected years at roughly ten-year intervals—1929, 1939 and 1950. It is concerned solely with the social origins of these senior Civil servants and, as a secondary issue, with promotion within the Service. It is not accordingly a book about the Higher Civil Service in the sense of Mr. H. E. Dale's earlier book. It is much more limited but contains an immense amount of data on the social background of the senior Civil servant from 1870 to the present day, covering the several routes of entry, the pattern of representation of schools and universities and the occupation of the fathers of the groups examined. There are also a brief review of the position of women in the Administrative Class and a comparison of the social characteristics of the heads of six departments in 1888, 1912, 1929 and 1950.

Mr. Kelsall's treatment of the data he has collected so carefully does not, however, match the assiduity with which it was assembled. His discussion is subjective rather than objective, and appears to be dominated, first, by the assumption that access to a post in the Administrative Class of the Service is a natural right of every citizen, and, second, that promotion from the ranks is intrinsically superior to examination entry as a method of recruitment. These assumptions are nowhere discussed, nor are their implications considered; but they colour Mr. Kelsall's discussion of the nature of the profession and thus rob it of any claims to be a serious contribution to the discussion of the adequacy of the Higher Civil Service to-day and what measures of reform are required.

These preconceived ideas prevent Mr. Kelsall from pausing to consider either the nature and limitation of the duties of the Administrative Class and the relation of such Civil servants to their Minister, or whether social background and traditions of certain groups may not give them certain inherent qualifications as public servants which are as much to the public advantage as to their own. That the Civil Service should be widely representative of the different sections of the community is all to the good. It is egalitarianism run mad, however, to suggest that the different sections should all be proportionally represented and to ignore the fact that a tradition of public service and political sense, at least as much as the resources to acquire a university education, have been responsible for generation after generation of certain classes or professions sending their sons into the Civil Service or Armed Services, just as it still supplies the great bulk of voluntary service.

In his essay in the *Political Quarterly*, Mr. Kelsall showed himself aware that recruits from certain classes might have their own faults and suffer from inherent disadvantages, but his obsession with egalitarianism and his conception of the ideal Civil servant as an imaginative, intelligent, forceful reformer, preferably trained in the social sciences, leads him to overlook the fact that if a Civil Service of high character and appropriate to the needs of to-day is to be recruited widely, the corollary to opportunity is a gradual raising of educational and cultural standards generally throughout the community which will even out not so much differences in wealth as in cultural outlook and standards. When the working class begins to provide voluntary workers in the way that the middle class has done for generations, we may expect it also to provide recruits for the Civil Service of the same calibre as the middle class has long been doing. The problem is not so much one of educational opportunity as of general education; nor has Mr. Kelsall really faced the difficulties inherent in the expanded promotion policy he advocates, and particularly the recruitment of the scientist to the Administrative Class.

R. Brightman

THE GLASGOW 340-MeV. SYNCHROTRON

By Dr. W. McFARLANE, S. E. BARDEN and Dr. D. L. OLDROYD
Department of Natural Philosophy, University of Glasgow

THE electron synchrotron housed in the recent extension of the Natural Philosophy Department of the University of Glasgow was first operated at its maximum energy of 340 MeV. in April 1954. By the end of that year the gamma-ray output had been built up to a very satisfactory level, and the machine is now being employed for experiments on the photo-disintegration of nuclei and meson physics. A general view of the machine is shown in Fig. 1.

The magnet, a side view of which is shown in Fig. 2, was designed and constructed by Metropolitan-Vickers Electrical Co., Ltd., Manchester. It consists of a circular arrangement of twenty C-shaped units providing an annular gap of mean radius 125 cm., radial width 18 cm. and mean height 10·16 cm., within which the vertical guide field is established. Each unit is constructed from five parts: one vertical and two horizontal blocks of laminations, and two pole-shoes with a profile calculated to give the required field gradient. Two of the units have extended horizontal members in order to provide an air-gap for the passage of the gamma-ray beam. The magnet top, comprising the twenty upper horizontal members of the C-units, their attached pole-shoes and one of the exciting coils can, by means of a mobile crane, be raised in one piece weighing about 40 tons in order to provide access to the vacuum chamber. Induction acceleration is provided by twenty saturable flux bars placed within the electron orbit and clamped by means of wedges to the inner faces of the C-units.

The betatron flux and guide field are produced by the oscillatory current arising from the discharge of a condenser bank (860 μF.) through the twenty-turn coil situated within the C-units. One complete oscillatory cycle takes place during each pulse, the frequency of pulsing being adjustable up to five times per second. The original condenser bank failed to withstand the above operating cycle at the maximum potential of 17 kV., and almost a year was lost in the development of the project while new condensers of higher tolerance were manufactured. The switching is performed by an ignitron switch built by British Thomson-Houston Co., Ltd. This employs eight *BK* 56 ignitrons, four in parallel carrying each half-cycle of current. The ignitrons which conduct the first half-cycle are triggered by a pulse synchronized to a sub-multiple of the 50 c./s. mains, while those which conduct the second half-cycle are triggered by pulses from a biased peaking transformer in such a way

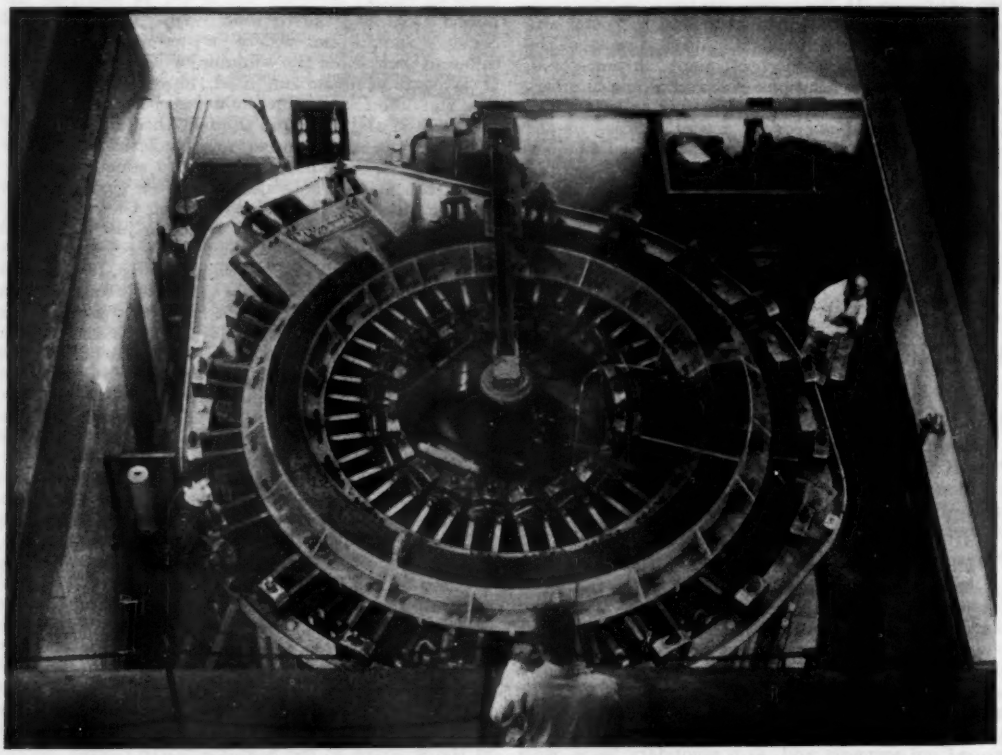

Fig. 1. The synchrotron chamber viewed from the crane hall. The machine is normally covered by a motorized sliding concrete slab which provides screening

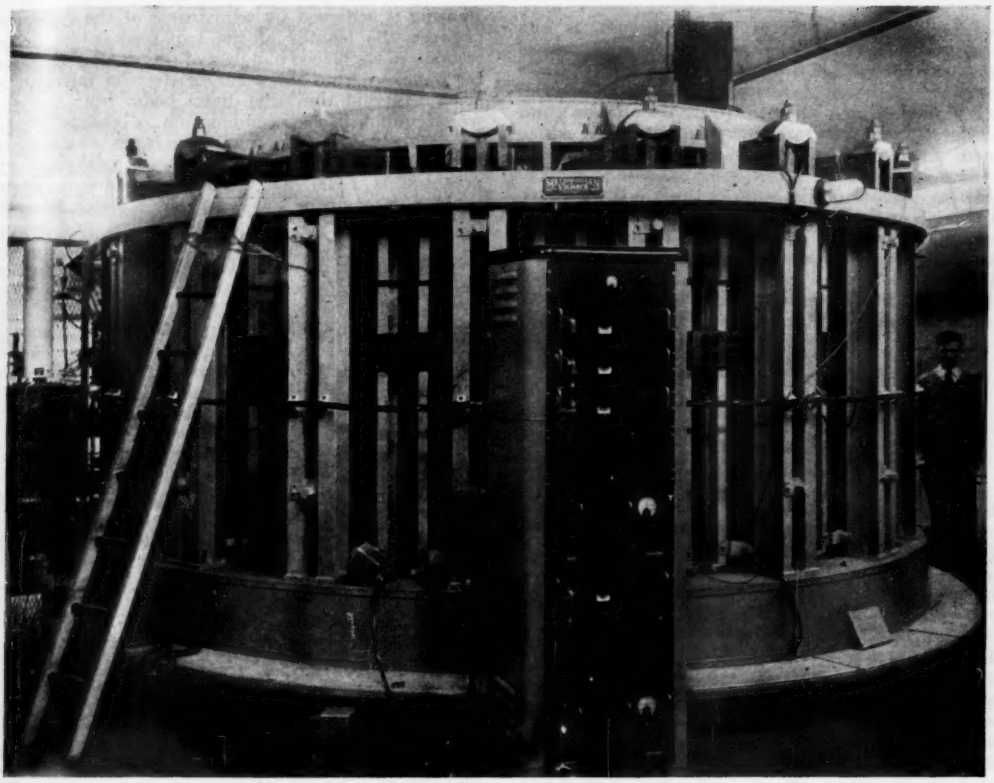

Fig. 2. Side view of magnet

that the magnet current passes smoothly through zero between the two half-cycles. At present the third quarter-cycle is the period during which electrons are accelerated. The average reactive power stored is 33 MV.amp., and the mean power-loss during pulsed operation is about 60 kW. The only cooling employed in the magnet is by forced air-draught upwards through the centre.

The charging current for the condensers is provided by a conventional three-phase hard-valve rectifier and passes through a series pentode valve (*E* 1807) which is used as a voltage stabilizer; the maximum voltage permissible is 17 kV. Operation at 16·4 kV. provides a peak magnet current of 3,750 amp., which gives the guide field of 9,000 gauss necessary for electrons of energy 340 MeV. to move in a circle of radius 125 cm. The magnet inductance is about 40 mH. during betatron acceleration, but decreases to about 15 mH. when the flux bars are saturated. Thus $dB/dt = 0{\cdot}8$ gauss/μsec. at field zero, but increases to a maximum of about 2 gauss/μsec. The energy gain per revolution during the betatron phase is initially about 850 eV., adjustable to ± 1 per cent by remote control of flux-bar reluctance. When the bars are saturated, the energy gain per revolution is about 1,700 eV., which determines the minimum for the energy supply from the resonators.

Guide-field focusing is provided by the radial field gradient $\frac{dB}{dr} = n\frac{B}{r}$, where $0 < n < 1$ over the annular region $r = 125 \pm 6{\cdot}5$ cm. in the median plane. Three main sets of correction coils are employed. Control of the average value of n around the complete orbit is provided by five concentric coils spaced 1 in. apart and attached to each pole face. The current through each of the ten coils is independently controlled so that median plane adjustments are also possible. Azimuthal variations of the radial gradient or the median plane can be removed, or introduced, by pole-face coils covering each of four quadrants situated at six radial positions 1 in. apart, alternating with the above set of circular coils. Azimuthal variations of remanent field or of rate of change of field associated with individual C-units are counteracted by resistance control of the currents induced in eight-turn coils around the vertical members of each unit.

The toroidal vacuum chamber (Figs. 3 and 4) is built up from moulded ceramic sections. There are nine plain sectors and eight with ports to provide access to the chamber, made of 'Frequentite'. The inner surface is coated with a thin continuous layer of platinum which has a resistance of 5–20 ohms per square. (The two resonators which complete the chamber will be described below.) The cross-section is roughly elliptical, with internal radial and axial dimensions 18 cm. and 6 cm., respectively, the wall thickness being about 1 cm. Adjacent sectors are spaced by 'Teflon' gaskets, the vacuum seal between them being provided by surrounding neoprene bands. Manufacturing tolerances reduce the clearance between the chamber and the pole-faces to about 0·5 cm. in places, leaving just sufficient space for the pole-face coils. The pumping system consists of a

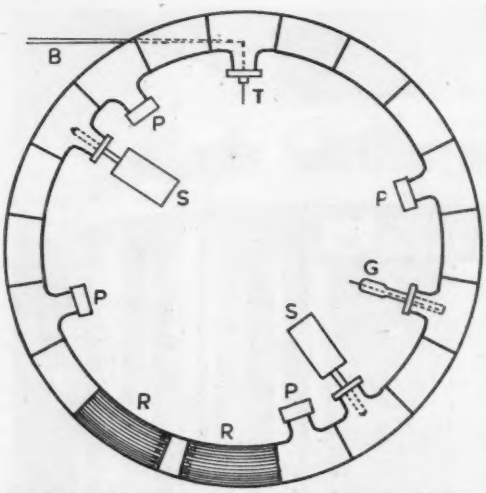

Fig. 3. Lay-out of vacuum chamber: *P*, pumping ports; *G*, electron gun; *S*, scintillator probes; *R*, resonator; *T*, target; and *B*, gamma-ray beam

Kinney rotary pump which provides the backing pressure for four 4-in. oil-diffusion pumps. The pressure in the vacuum chamber is usually about 2×10^{-6} mm. of mercury.

Electrons are injected from a diode gun inserted through a port on the inner edge of the vacuum chamber. The anode is earthed, and the directly heated cathode is supplied with a negative trapezoidal pulse of duration about 5 μsec. and of amplitude about 70 kV. Up to 1 amp. of electronic current can be injected. Three motorized, remotely controlled adjustments permit the optimum disposition of the gun and its electrodes to be found during machine operation, these adjustments being radial movement, rotation and movement of the cathode relative to the anode. During the periods of rise and fall of the anode potential, a considerable number of low-energy electrons strike the inner wall of the sector housing the gun, ultimately causing sufficient damage to the metallized coating to produce erratic behaviour of the output. Repairs to this section are necessary at intervals of a few months. The timing of the injector pulse must be accurate to within 0·1 μsec. in order to maintain a steady output. This is achieved by feeding a pulse produced by a peaking strip mounted within the magnet gap into a multiar circuit which permits adjustment of timing within a selected limited range. The period during which electrons are accepted is about 0·4 μsec.

Synchronous electron acceleration is obtained by using two quarter-wave coaxial resonators. The conductor consists of a silver coating of at least 0·001 in. thickness, which is divided into strips about 1 cm. wide by longitudinal scribe lines in order to reduce eddy-currents. The lines on the inside are covered with a high-resistance film of 'Aqua-dag' to prevent charge accumulation. The resonators are fed, matched and tuned with the aid of two π-shaped slots in the outer silver coating. The gap across which the accelerating voltage is developed is located near one end. The two resonators with a small make-up sector between them occupy the same azimuthal angle as three normal sectors. They are placed with the accelerating gaps close together so that they must be fed approximately in anti-phase. Phasing is achieved by adjustment of the difference between the lengths of the two feed cables. The resonators are placed in a part of the vacuum chamber far removed from the point of electron injection in order to avoid the large direct beam from the gun which might cause accumulation of charge on the insulating gaps. The frequency range necessary is $38{\cdot}2 \pm 1{\cdot}6$ Mc./s., and the minimum total peak-gap potential is 1,700 V. The radio-frequency power source consists of a small master oscillator followed by two stages of frequency-doubling and power amplification, and a final push–pull output stage operated under class *C* conditions. The modulator pulse which is applied to the grid of the first doubler circuit is supplied from shaping circuits which provide control over the rate at which the radio-frequency voltage rises, its duration and the rate at which it falls. Timing is adjusted by means of delay circuits triggered from the instant of zero magnetic flux. It is found that betatron-synchrotron transition usually commences when the electron energy is about 4 MeV. with a radio-frequency of 38·3 Mc./s., the betatron orbit radius at injection being about 126 cm. The γ-ray beam is normally obtained by switching off the radio-frequency supply near peak field and allowing the circulating electrons to spiral inwards and strike a tungsten target. Sudden cut-off provides a beam of about 30-μsec. duration, but by shaping the trailing edge of the modulator pulse a duration of about 2 msec. can be obtained.

The comparison of the γ-ray outputs of electron synchrotrons working at energies of about 300 MeV. has been done in two ways. One method consists of measuring the number of 'roentgens' observed on the axis of the beam at a distance of several metres, using a Victoreen ionization chamber surrounded by a thimble of lead ¼ in. thick and expressing the axial intensity in roentgens per minute at one metre. The Glasgow machine can produce a steady output of 2,000 r./min. The other method makes use of a large ionization chamber with walls of copper 1 in. thick, this thickness being chosen to provide maximum electron shower intensities for 300-MeV. γ-rays. Such a chamber has been calibrated at Cornell University in terms of the number of equivalent quanta per coulomb of collected charge. The number of quanta measured by this chamber depends on the angular width of the beam, which is controlled by an aperture in a lead collimator. On the basis of the Cornell calibration of an identical chamber, the synchrotron has an output of 2×10^9 equivalent quanta per minute through an aperture of diameter ¼ in. situated 125 cm. from the target.

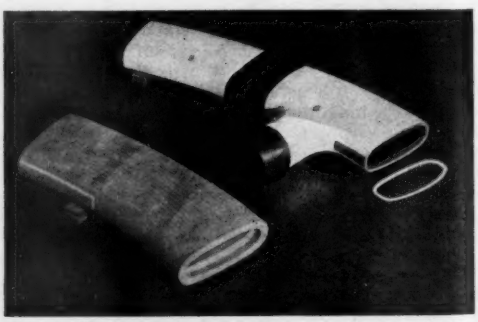

Fig. 4. Component parts of the vacuum chamber: a plain and a port sector fitted together, and a resonator

A project of this magnitude necessarily involves such a large number of workers that space permits an acknowledgment of only the principal contributors to the success of the installation. Throughout the development and constructional stages, the project was controlled by a committee under the joint chairmanship of Prof. P. I. Dee and of Mr. F. R. Perry, of the Research Department, Metropolitan-Vickers Electrical Co., Ltd. The members of the committee were drawn from the University, many departments of Metropolitan-Vickers, the Atomic Energy Research Establishment, Harwell, and several industrial firms responsible for the manufacture of different parts of the project. The magnet was designed by J. B. Hansell and the measurements and adjustments were supervised by E. A. Finlay. D. W. Fry, F. K. Goward and R. Carruthers, all of Harwell, who had been associated with the construction of the first successful electron synchrotron, were members of the committee. The ceramic vacuum chamber and resonators were manufactured by Steatite and Porcelain Products, Ltd., with the co-operation of R. Carruthers, who was also responsible for the design and manufacture of the radio-frequency and other electronic circuits. The electron guns, the prototype of which was designed at Harwell, have been modified and improved by A. C. Robb and J. T. Lloyd, of Glasgow. The task of designing the magnet corrections and of finding and improving the beam was the work of the authors of this article. A more complete report of this work will shortly be published elsewhere.

DEFINITION OF THE SECOND OF TIME

By Sir H. SPENCER JONES, K.B.E., F.R.S.

WITH reference to the letter by Sir Edward Bullard published in *Nature* of August 13, p. 282, the General Assembly of the International Astronomical Union, held in Dublin in September, passed a resolution approving the definition of the second proposed by the Comité International des Poids et Mesures, as follows:

"The second is the fraction 1 : 31 556 925·975 of the length of the tropical year for 1900·0."

This fraction is sufficiently accurate for all practical purposes, but it should be noted that the more precise value required for exact agreement with Newcomb's Tables of the Sun is 1 : 31 556 925·97474.

The physicist and the radio engineer will desire to know how the mean solar second of to-day can be related to the second, adopted as the unit of time in the above resolution. The following explanation has therefore been prepared by Commission 31 (Time) of the International Astronomical Union:

Mean solar or Universal time, based on the rotation of the Earth, is obtained in practice from observations of stars. Ephemeris time, basically the independent variable of the equations of motion of celestial bodies, is the time argument of astronomical ephemerides. The second of Ephemeris time is the unit of time defined in the resolution passed by the International Astronomical Union. The comparison of ephemeris positions of suitable celestial bodies with observations recorded in Universal time serves to obtain the difference Δt, Ephemeris time minus Universal time.

In practice, Ephemeris time is determined as the time at which an observation of the Moon is in agreement with the lunar ephemeris constructed in conformity with the internationally adopted solar ephemeris. For the years 1952–59, this lunar ephemeris is published in the volume "Improved Lunar Ephemeris, 1952–1959"; from 1960 onward it will be published annually in the National Ephemerides.

In order to obtain a frequency ν_E corresponding to the invariable unit of time defined in the resolution, the following steps are required:

(*a*) The frequency ν_U is obtained by using as unit of time the second of Universal time provided by wireless time signals issued by the national time services.

(*b*) Corrections to these time signals, obtained afterwards from observations of stars, are published regularly by the time services. Inter-comparisons of the time signals transmitted by the various observatories are published annually by the Bureau International de l'Heure.

(*c*) Values of the difference Δt, Ephemeris time minus Universal time, applicable to the middle of each year, are being published with a lag of from two to three years. They are at present derived from observations of occultations of stars by the Moon, and meridian observations of the Moon. It is expected that in the near future a programme of observations with dual-rate Moon position cameras, developed by Markowitz at the U.S. Naval Observatory, will provide a method of deriving the difference Δt more accurately and more promptly.

(*d*) Let $D\Delta t$ designate the change per annum in the value of Δt, derived by a suitable formula for numerical differentiation from a sequence of annual values of Δt. If Δt is expressed in seconds, the frequency ν_E corresponding to the second defined in the resolution is then obtained by:

$$\nu_E = \nu_U \left(1 - \frac{D\Delta t}{31{,}556{,}925{\cdot}975}\right)$$

$$= \nu_U \, (1 - 3{\cdot}1689 \times 10^{-8} \, D\Delta t)$$

(*e*) After the frequency of an atomic frequency standard has been determined to sufficient accuracy with respect to the second of the resolution, the atomic standard may be used to make the second immediately available.

The astronomical determinations of time are complicated by seasonal variations in the rate of rotation of the Earth as well as by the polar motion. These causes contribute to the discordances among the determinations of time at various observatories. Definitive corrections for these effects can at present be effected only with a lag of several years. Provisional corrections can, however, be applied at once, with a resulting uncertainty in Universal time at most of the same order as the uncertainty in the annual values of Δt.

Laboratory determinations of frequencies corresponding to the varying second of Universal time may aid importantly in the study of the seasonal variations in the Earth's rate of rotation.

When the relationship between the mean solar second at the present time and the second defined in

the resolution of the International Astronomical Union has been satisfactorily determined, the cæsium frequency standard developed at the National Physical Laboratory will enable the mean solar second in future years to be related immediately to the fundamental unit of time.

As Sir Edward Bullard remarks, the atomic frequency standard will provide a check within a few years whether or not there is any divergence between astronomical and atomic time, and will thereby provide a test of the theories of Milne, Dirac and Jordan.

WELSH PLANT BREEDING STATION

NEW HEADQUARTERS AND EXPERIMENTAL GROUNDS

By Prof. E. T. JONES
Director

THE new headquarters and experimental grounds of the Welsh Plant Breeding Station at Plas Gogerddan were opened by H.M. The Queen, who was accompanied by H.R.H. The Duke of Edinburgh, on August 8 in the presence of more than one thousand guests.

Founded in 1919 as a research department of the University College of Wales for the investigation and improvement of farm crops, the Station owes its existence to foundation gifts to the College by Lord Milford of Llanstephan House, Radnorshire. Apart from these initial gifts, the research programme is supported financially by Treasury grants made by the Ministry of Agriculture, Fisheries and Food on the recommendation of the Agricultural Research Council.

The primary activities of the Station concern the breeding and development of new strains and varieties of grasses, clovers and oats. Valuable contributions to British agriculture have been made by the staff in the production of new varieties of farm crops, the development of new techniques in the establishment, manuring and management of grasslands, and the improvement of hill pastures. The Station has also carried out researches in seed-growing techniques, and has introduced seed-crop inspection and certification schemes. The aim of these is to ensure that the Station-bred strains are made available to farmers as authentic seed of the highest standard of purity. Much of this pioneer work has been of the greatest value in relation to the problems of grassland scientists in many parts of the world.

Plas Gogerddan became the new home of the Station when the University College of Wales purchased a major portion of the Gogerddan Estate in 1950. With the aid of funds provided by the University Grants Committee, the mansion (Fig. 1) has been renovated and converted into laboratories for chemistry and cytology, library, conference and common rooms, and offices for administrative and other staff. Residential quarters for the Director, or a senior research officer, and for a caretaker are also available.

Capital grants for the construction of greenhouses, field laboratories and the Lord Milford Plant Research Laboratories have been provided by the Ministry of Agriculture, Fisheries and Food. The new greenhouses, which are of cedar wood and of standard design, are in three separate blocks built to meet the needs of the Grass, Clover and Cereal Breeding Sections, respectively. A supplementary unit with lighting and heating equipment is provided in the Grass Breeding Section for the control of the flowering period in plants used for hand-crossing, and a central service block houses the boilers, soil sterilization units, potting benches and other ancillary equipment.

The heating of the greenhouses is by low-pressure steam raised in a locomotive-pattern boiler, which is automatically fired by a solid fuel underfeed stoker. Steam is carried by mains to pipe coils in the greenhouses and by branches from the mains to feed a calorifier in each of the laboratory blocks. The calorifiers consist of a cylinder with an inner heating coil, and by means of an electrically operated pump the steam-heated water in the cylinder is circulated through the laboratory radiators. These are arranged to give an internal room temperature of 60° F., with an external temperature of 30° F., and a low-pressure hot-water flow temperature of 180° F. Each calorifier is fitted with a thermostatic valve on the steam supply connexion, with steam trap, strainer and check valve. The steam boiler also provides steam to service two steam grids each 5 ft. square for soil sterilization, and steam jets for pot sterilization.

The field laboratories, which are adjacent to the greenhouses, consist of one-story units of simple and essentially functional design. In addition to office and laboratory rooms for scientific and technical

Fig. 1. Plas Gogerddan

Fig. 2. Lord Milford Laboratories

Topical Press

staff, there are facilities for students and overseas workers to pursue training in plant breeding or schemes of research in collaboration with the Department of Agricultural Botany for higher degrees of the University of Wales.

The Lord Milford Laboratories (Fig. 2) have two floors and a basement and provide a total floor space of about 12,000 sq. ft. This building is built of brick with a rough-cast exterior and reinforced concrete floors surfaced with 'Accotiles'. It provides storage for cereal breeding material and herbage seeds, as well as laboratories for the Cereal, Seed Multiplication and Grassland Agronomy Sections. In the basement there are rooms for the long-term maintenance under controlled low-temperature conditions of special stocks of breeders' material, rooms with controlled lighting for the study of plant reactions to light, a boiler room and facilities for the threshing of oats and other grains.

By arrangement with the University College Estates Committee, adaptation and repairs to the farm buildings are in progress for the housing of cattle required for the field experiments, and for the installation of a series of three 'Unitherm' driers for the determination of the dry matter content of herbage samples. The hunter stables and coach houses have been converted into shops for the carpenter and mechanics and to house farm implements and farm machinery.

The home farm of Plas Gogerddan extends over approximately 200 acres, which, with the retention of the Frongoch Experimental Farm of 96 acres and the release of Brynamlwg Farm to the University College, leaves a net gain of more than 120 acres highly suited to the development of large-scale field experiments.

Multiplication of foundation seed of bred strains will continue to be undertaken at Morfa Mawr, a farm of 460 acres on the coast eleven miles south of Aberystwyth. Apart from an initial grant for stocking and the installation of seed-cleaning machinery, this farm, which is let to the Station by the University of Wales for seed-growing purposes, receives no financial assistance in respect of maintenance and capital expenditure.

A new Hill Nursery of 45 acres recently made available will provide facilities for the study of the behaviour and relative growth of herbage, cereal and *Brassica* breeding material under semi-upland conditions, and for the comparison of plant growth under the latter conditions with that at a lowland centre.

The new headquarters and experimental grounds provide excellent facilities and make an ideal centre for the immediate and future development of the Station's research programme.

FUNGI IN FORESTS

IN a joint session with Section K (Botany) of the British Association, Section K* (Forestry) organized a discussion, held on the morning of September 5 in Bristol, at which the subject of "Fungi in Forests" was considered. Prof. Lily Newton was in the chair. The first of the four papers, that by Dr. I. Levisohn (Bedford College, London) on ways of studying the activity of mycorrhiza-formers in the soil, emphasized the difficulty of proving the relationship between the fungal and tree partners in mycorrhizæ of forest trees and commented on the fact that few, if any, endotrophic mycorrhizal fungi of trees have been isolated. Isolation of the fungus from ectotrophic mycorrhizæ has been achieved in a number of instances: by isolation from the fungal sporophores; by direct isolation from the mycorrhizal roots; and from hyphal strands or rhizomorphs directly connected with the mycorrhizæ. Identification of the fungus can often be made through comparison of mycelial cultures taken from the mycorrhizal roots with those from sporophores of known species. Inoculation of isolates on to tree roots is also desirable.

A number of known mycorrhiza-formers have been studied in the free-living state in field and pot experiments, and lively growth has been observed on a variety of decomposing organic material. Certain mycorrhiza-formers, such as *Boletus scaber* and *Rhizopogon luteolus*, have been shown to be capable of influencing root morphology and shoot development of a variety of tree species even when contact, and consequent formation of mycorrhizæ, was prevented. Pine roots responded by forking, and monopodial systems developed in larch and spruce roots. These ectotrophic mycelia also stimulated seedling growth of certain species of tree in which the mycorrhizæ are normally endotrophic—for example, Lawson cypress, *Thuja* sp. and *Robinia pseudacacia*. *Robinia* normally has both endotrophic mycorrhizæ and root nodules inhabited by nitrogen-fixing bac-

teria. Inoculation with either crushed nodule material or *Boletus scaber* gave improved growth of the seedlings.

Dr. Lilian E. Hawker (University of Bristol) then read a paper on hypogeous fungi, in which she gave an account of the collection of truffles and other hypogeous fungi by members of the Department of Botany, Bristol. The Bristol area was well worked by Broome some hundred years ago, so that it is not surprising that few new British records and fewer new species have been added to the list. The mature fruit bodies of ascomycetous (Tuberales, Plectascales), basidiomycetous (Hymenogastrales) and phycomycetous (*Endogone*) hypogeous fungi are strikingly similar and consist of a central sporogenous mass, or gleba, and an outer rind or peridium. These give little clue to systematic position; but comparison with less complex species and, above all, developmental studies have established the relationships of most species. Nevertheless, development has been followed in a comparatively few species, and modern work, particularly in France, suggests that the hypogeous Basidiomycetes, in particular, may be a very heterogeneous collection containing both simpler and reduced forms of diverse relationship. Dr. Hawker illustrated this with a series of lantern slides and by a demonstration of drawings, specimens and microscopic preparations.

Owing to the great difficulty of culturing most of these fungi, direct proof of mycorrhizal relationships with higher plants is lacking, but constant association between certain species of hypogeous fungi and certain trees is suggestive. For a similar reason, no exact physiological experiments have been done with cultures proved to be of hypogeous fungi, but identical isolates from mycorrhizæ of beech and fruit-bodies of *Tuber* spp. have shown nutritional characters similar to those of known mycorrhiza-formers. Since well over a thousand separate collections have been made during the past five years, the commoner species have occurred many times. Data of tree cover, soil and weather conditions were recorded for each collection, so that some idea of the factors controlling distribution of the commoner species has been obtained. Thus, while the majority are favoured by alkaline soils, a few—such as *Elaphomyces granulatus* and *Rhizopogon luteolus*—are found mainly in more acid situations. A well-aerated soil is essential for all species, although some are more exacting than others. Fruit-bodies, however, frequently form in contact with hard surfaces such as roots, path edges or clay layers. Both temperature and soil moisture are important factors in fruit-body initiation and maturation, although some species are more tolerant of drought and cold than others.

Miss R. M. Godfrey (University of Bristol) discussed some woodland species of *Endogone*. Arising out of the work described in the previous paper, Miss Godfrey has made a special study of the interesting phycomycetous genus *Endogone*. This genus includes forms producing zygospores, as a result of conjugation between gametangia, in groups within a loosely constructed fruit-body, and others producing similar fruit-bodies containing only chlamydospores. A single example was described by Thaxter of a species in which the fruit-body contained both types of spore, thus justifying the inclusion of the chlamydosporic forms in the same genus. Miss Godfrey was able to show slides of a specimen found by her at Cleeve Coombe, Somerset, believed to be a fruit-body of the normally chlamydosporic *E. microcarpa* containing a number of zygospores scattered among the typical chlamydospores.

British records, hitherto, have been limited to the zygosporic *E. lactiflua* (with a single doubtful and unsubstantiated reference to the zygosporic *E. pisiformis*), and the two chlamydosporic species, *E. microcarpa* and *E. macrocarpa*. To these Miss Godfrey has added an undoubted specimen of *E. pisiformis* collected by Dr. J. Fraymouth in the New Forest and two species in which the chlamydospores show characteristic grouping, believed to be *E. fuegiana* and *E. vesiculosa*. The great variability of spore characters shown by *E. macrocarpa* was also pointed out. The genus *Endogone* is of interest both from the systematic and biological points of view. The zygosporic forms show affinity both with the Mucorales, with which they are provisionally classified, and the Hemi-Ascomycetes. If zygospores could be germinated the results would be of primary significance, since, if on germination they gave rise to a sporangium, their relationship with *Mucor* would be established; but if they should germinate by the formation of endogenous spores, they might be considered to have a closer affinity with the simple Ascomycetes. Unfortunately, no one has as yet succeeded in inducing germination of zygospores by any of a large number of techniques. Miss Godfrey, however, was able to report germination of chlamydospores of both *E. microcarpa* and *E. macrocarpa*. These germinate to produce a typical coarse mycelium with characteristic branching.

In conclusion, Miss Godfrey pointed out that a study of the mycorrhizæ of plants growing near the *Endogone* fruit-bodies (including yew and species of *Viola*) did not yield any conclusive evidence in support of Peyronel's thesis that *Endogone* spp. are the endophytes forming the vesicular-arbuscular type of mycorrhizæ with various flowering plants.

In the final paper, Prof. C. G. C. Chesters (University of Nottingham), speaking on the fungal population of bark of living trees, recalled the fact that when a branch of a tree is shed, either from natural causes or through forestry practice, it is rapidly colonized by one or more microfungi. Such fungi may be termed the flora of 'first incidence'. Whole saplings may be colonized with a single bark-inhabiting fungus such as *Diaporthe leiphemia* on beech, or a number of these may occur. Some are confined to a single tree species—for example, *Diatrype disciformis* on beech—while others may be termed 'plurivorous'—for example, *Valsa ambiens*. Such a constant association between certain species and the bark of dead tree branches suggests that the inoculum must already be present on the living tree before the branch is shed. Washings of bark of various trees yielded spores of these species, but there was a predominance of spores of such species as *Pullularia pullulans* and *Cladosporium herbarum*. With repeated washings the proportion of spores of these species increased. Examination of fissures in the bark and of lenticels showed the presence of chlamydospores and mycelium. It is of interest that Smit and Wieninga (1953) also obtained *P. pullulans* from washings of dead leaves, and it is likely that this fungus is concerned in pectin decomposition.

In the discussion, unfortunately limited by the time allowed, which followed each of these papers, Dr. J. Ramsbottom and others emphasized the change in our concept of 'symbiosis'. Modern work supports the idea of a precarious balance, or controlled parasitism, between the two partners of a 'symbiotic' system.

LANGUAGE, MEANING AND MIND

At the Bristol meeting of the British Association, a symposium on semantics was organized by Section J (Psychology). In Great Britain semantics has tended to remain a topic of philosophical parlour conversation, except among linguists for whom it has been rather a technical discipline. Among empirically minded scientists, especially psychologists—who are more severely empirical than any to-day—semantics has come to be regarded as a rather fancy line of talk devoid of both rigour and content. The aim of this symposium, in which the disciplines of psychology, linguistics, neurology and mathematical logic were represented, was to demonstrate not only a measure of common ground among these disciplines, but also to indicate that semantics is now sufficiently developed to provide psychology with a much-needed methodological instrument. It is an instrument with applications as far-reaching and precise as those of statistics, and is, indeed, a necessary complement to the latter if figures are to have meaning. Moreover, it is not without its bearings on the hotly debated theme of the "Fragmentation of Science" so provocatively presented at Bristol by Mr. Ritchie Calder.

In the opening paper on "Semantics in Relation to Psychology", Prof. G. P. Meredith traced in outline the history of the 'theory of signs' from its early beginnings in Greek medicine down to its present systematic development in the hands of Morris and Carnap. The signifying function of words is seen as an instance of a much wider semantic phenomenon, namely, the interpretation of signs of all kinds. This communication of meanings is a fundamental biological process essential to animal societies. To clarify this study of 'semiotic', as it is called, Morris, following Charles Peirce, has divided it into three main branches: syntactics investigates the relations of signs among themselves; semantics deals with the relations of signs to the objects signified; and pragmatics is concerned with the relations of signs to interpreters. These divisions, which correspond with the famous triangle of "Thought, Symbol and Referent" of Ogden and Richards, are represented in Fig. 1. Thus relations are the essential theme of semiotic studies. A word bereft of relationship is a mere physical event.

Carnap has developed semantics in terms of symbolic logic. In a highly abstract system he has presented the pure mathematics of language. This system, though lacking immediate applicability, may well be needed in the future society of universal and virtually instantaneous polyglot communications. Carnap will play Riemann to some future Einstein of social space-time.

Meanwhile, the discipline of semantics as developed by linguists can provide psychology with valuable discriminations. Ullmann, in his "Principles of Semantics", provides a three-dimensional classification of the fields of linguistic inquiry based on: the level of complexity (as in phonology, lexicology and syntax); the transverse or longitudinal aspect of language in time (synchronistic or diachronistic); and forms or meanings (as in morphology and semantics). If we extend this treatment to visual as well as auditory signs, we have the 'semiotic cabinet' of Fig. 2.

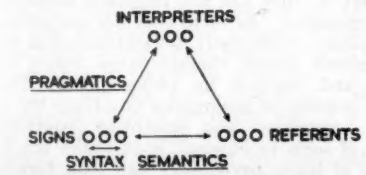

Fig. 1. The semiotic triangle

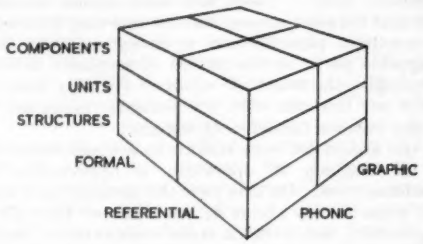

Fig. 2. The semiotic cabinet

Such schemes can suggest valuable frameworks for the design of psychological experiments and studies of such problems as aphasia as well as normal linguistic development in childhood. They can help to resolve the many terminological problems which beset psychology, and also to break down the barriers of jargon which hinder its relations with other sciences. Finally, the fundamental difficulties which arise from the categoreal diversity in thoughts, words and things, and from the 'systematically misleading expressions' discussed by Gilbert Ryle, may, through semantic analysis, give way to a system of empirical type-differences, a system urgently needed in modern psychological theory.

Prof. Stephen Ullmann, in his paper on "The Concept of Meaning in Linguistics", took his stand (appropriately enough in a psychological symposium) on the non-self-sufficiency of linguistics for resolving the nature of 'meaning'. Psychology and neurology, philosophy, anthropology and social science, all have a stake in this problem. He discussed two main approaches to the problem, the analytical and the operational, and showed that these are ultimately more complementary than contradictory.

Discussing the triangle of Ogden and Richards, in which the relations between the 'name', the 'sense' and the 'thing' are expressed, Prof. Ullmann simplified the issue by dismissing the 'thing' as non-linguistic. We thus are left with a binary and reciprocal relation between the name and the sense. The speaker starts with the sense. In him the sense calls up the name. The hearer starts from the name, and in him the name calls up the sense. The link between name and sense is severed only in the brain lesions studied by neurology. An over-simplified view which asserts some direct relation of designation between the name and the thing creates insuperable difficulties by ignoring the way in which language, in fact, works. The word 'atom' does not mean to-day what it meant to the Greeks, though the atom itself has not changed.

It is the concept which has changed. A more serious objection to the analytical dichotomy of sense and name is that it seems to imply a mysterious psycho-physical relation. There certainly is an inherent duality in language or in any sign-system, between the sign and that which is signified; but name and sense are not, in fact, heterogeneous. The name is not the physical event but the mental impression of the word. Both name and sense are mental phenomena.

There are weaknesses in the analytical view. One is the fact of polyvalency. One name may have several senses. One sense may be expressed through several names. The view thus needs elaboration. More fundamental is the objection that the view is atomistic and fails to account for the all-important determination of context. Every word has its 'associative field'. There are associations between names and between senses, and the two may intersect. This complex phenomenon is being resolved into manageable parts by the notion of semantic fields—for example, the scale of colours. (It may here be pointed out that the effective semantic fields are, in fact, the various branches of science.)

As the analytical view widens to accommodate the facts of language in operation, it approaches the operational view. On this view the meaning of a word is not what we say about it, but what we do with it. Wittgenstein, not without some reservations, identified the meaning with the use of the word. On this view meaning is not revealed by use, it is itself the use. Thus the influence of context, which is embarrassing to the analytical view, is the very basis of the operational view. Words apart from context are abstractions. The operational view is thus closer to the facts of language in action. However, we do use dictionaries, and the lexicographer, though starting operationally from linguistic facts, finishes with an analysis of discrete meanings. Thus the analytical view has its part to play. Words have been likened by Wittgenstein to tools, and by de Saussure to chessmen. Both similes suggest a range of relationships, a 'field of force', facilitating a structural view of language. Such a view can do much to facilitate the relations between linguistics and the neighbouring disciplines.

Sir Russell Brain revealed the intricacy and subtlety of the problems thrown up by neurological disturbances in his paper on "The Semantic Aspects of Aphasia". The difficulty of the linguists in finding an adequate definition for the term 'word' is matched in neurology by the difficulty of finding a firm physiological substratum the behaviour of which, both in order and disorder, can account for all the elusive phenomena of aphasia. Here again, the determining role of context is in sharp evidence. Also the neurologist has to be on his guard against being misled by his own language in formulating both the symptoms and the problems.

In aphasia words become less available for use, in varying degrees. The patient may fail to produce a word on request, but may say it under stress of emotion, or in another context. Also, he may recognize it when presented to him and reject wrong alternatives. Or he may have very few words available and yet contrive to use them, with or without gestures, to convey a correct answer to a question. Formulating a proposition is thus partly independent of particular words; and thinking, though in the long run very much dependent upon command of language, may go on in spite of word-failure. In some cases the choice of words becomes 'liquid', one word masquerading for another—for example, a more general for a more specific word. Or again, the word may be heard as a meaningless sound. Analogous failures occur in speaking, reading and writing.

In every word there is a constant element and two variable elements. On one hand the word as heard may vary in pitch, volume, pronunciation or intonation; on the other hand, it may enter, through sentences, into many different contexts, having numerous associational meanings. Between these variables of sound and meaning there must exist a constant pattern, a fixed atomic element. The term 'auditory word-schema' is given to this fixed element. The schema is conceived as a physiological disposition: it does not itself enter consciousness, but it does determine verbal awareness.

From reading, again with its variety of visual forms, we similarly have for each word a 'visual word-schema'; and on the expressive side we have motor schemas for speaking and writing. These schemas functioning together give us a 'central word-schema'. This theoretical framework of the central schema related through receptive and expressive schemas to incoming and outgoing language, and, through associative links, to meaning and thought, provides a physiological basis for the very diverse disturbances of language, from the most specific and superficial to the most serious and far-reaching disorders. In these last the central word-schemas are disorganized, and the capacity to evoke meanings has gone. Thought is thus inevitably impaired. In the more superficial disorders, involving one channel of communication only, thinking may not be much affected. These verbal schemas, however, being physiological, and therefore unconscious, may, through their evocation of meanings, play a part in what, to consciousness, is 'non-verbal' thinking. When schemas are damaged, the effects may not, therefore, be confined to linguistic behaviour only. In the normal state they play their part in the facilitation of apparently non-verbal thought-processes.

In the concluding paper of the symposium, on "Semantics, Pragmatics and Behaviour", Dr. F. H. George made a plea for a more sophisticated view of semantics than the popular notion that identifies it with merely being careful to define our terms. Language can be reconstructed according to systematic rules. Taking a behaviourist point of view, he located the phenomena of 'meaning' firmly in the organism. Thus private introspective statements can be used scientifically only in so far as they are clearly associated with statements concerning public data. But the latter often misses the core of behaviour, whereas the former appears more relevant. The psychologist must reconcile the two worlds or, in other words, the two languages. Only through rigorous formalization can the inconsistencies between the two be eliminated. Statements within a theory must be distinguished from statements about a theory. Philosophical statements are statements by philosophers, that is, they are the linguistic behaviour of certain organisms. As such, they are subject-matter for psychology. Conversely, the statements of psychologists present formal characteristics which can be analysed and clarified by philosophers. Through this twin activity of pragmatics (studying the use of signs by organisms) and semantics (studying the reference of signs to objects), both under the formal discipline of logic, psychology can look forward to healthy progress.

G. P. Meredith

NEWS and VIEWS

Mr. G. A. Stewart, M.B.E.

Mr. G. A. Stewart, assistant secretary and librarian of the Royal Society of Edinburgh, is retiring from his duties there on October 12 after more than fifty years of service. This service has been continuous except during the period of the First World War, when Mr. Stewart participated as a member of the Royal Scots in the campaigns in Gallipoli, Palestine and France, and was "mentioned in dispatches". Public recognition of the value of his work to the Royal Society of Edinburgh was afforded recently by the award of the honour of M.B.E. Only the senior officers of a scientific society, however, really know what a boon it is to have constantly at hand a capable and conscientious guide for every question, major or minor, on which decision must be taken. The devotion and experience of Mr. Stewart have indeed proved of inestimable assistance to the Council of the Royal Society of Edinburgh since the time of Lord Kelvin. Best wishes will be accorded him, not only by Fellows of the Society itself, but also by many members of other bodies whom he has cheerfully aided with loans of books from the extensive library under his charge, for happy years of well-merited leisure in his retirement and of success in his favourite sport of fishing.

Virus Studies in The Queen's University, Belfast

After the appointment of Dr. G. W. A. Dick to the chair of bacteriology (now called microbiology) at The Queen's University of Belfast, it was decided that virus work would be undertaken in the Department. The University undertook considerable alterations of the existing accommodation in order to provide a virus laboratory with a sterile room, hot room, etc., and also animal accommodation. In addition, a grant of £3,000 was made by the University to assist in equipping the Department for bacteriology and virus work. Since no virus work had previously been done in Northern Ireland, a considerable amount of basic equipment had to be obtained, and a grant of 21,000 dollars has been made for this purpose by the Rockefeller Foundation. This money is being used to purchase, among other things, a 'Spinco' centrifuge, an 'International' refrigerated centrifuge, a $-70°$ C. storage box, a cage sterilizer, a water demineralizer and microscopes.

Two lines of virus research work are going to be undertaken. One of these is concerned with the problem of latent virus infections based on the mouse hepatitis model (Gledhill and Dick, *J. Path. and Bact.*, **69**, 311; 1955) and the other is on poliomyelitis. To assist with this latter study, the National Foundation for Infantile Paralysis has awarded a research fellowship to The Queen's University which is being filled by Dr. D. Surrey Dane, and a salary has been provided for a technical assistant, Miss M. Briggs. The poliomyelitis research has started with the co-operation of Dr. W. J. McLeod and county medical officers of health in an epidemiological study of the distribution of antibody to poliomyelitis in the north of Ireland. The latent virus studies are not yet commenced. When the above research projects are under way, it is intended that a diagnostic virus laboratory will also be established, which will assist in diagnosis and in epidemiological studies of virus diseases in the north of Ireland.

British Colonial University Institutions

In a pamphlet entitled "Foundations of Freedom: the New Universities Overseas" (British Commonwealth Affairs No. 10; pp. 19. London: Longmans, Green and Co., Ltd., 1955; 1*s*. 6*d*. net), Sir James Duff makes some interesting comments on progress since the Asquith Commission on Higher Education in the Colonies reported in June 1944. The pamphlet also supplements the recent review by the Inter-University Council for Higher Education Overseas. Sir James stresses the need for a balanced system and the way in which technical colleges, under the title of colleges of art, science and technology, are being fostered to bridge, for the present, the gap that exists in the Colonies between secondary school and university. So far, the Inter-University Council has succeeded in keeping a clear dividing-line between these colleges and the university institution; and at Fourah Bay College, Sierra Leone, where both university and technical work have been included, there seem to have been real advantages. The difficulty in recruiting worthy staff has not materialized, largely because very hard and effective work at the Council's London office has ensured the finding of good recruits and their subsequent promotion on return to Great Britain. The number of students is growing steadily, and most British universities tend to limit their quota of Colonial students to those seeking higher degrees or studying subjects not available locally. Sir James stresses the part which the graduates of the Colonial university institutions must play in supplying the intelligent leadership which the Colonies need as they advance towards self-government and its importance if the institutions are to maintain high standards and academic autonomy. He notes, too, the financial problem set by the high cost of the colleges, capital and recurrent, and the low national income of the territories concerned, and questions the soundness of such decisions as that to build a hospital and medical school at Ibadan to satisfy the training requirements of the University of London. Sir James believes that the suggestion he advanced as a member of the Asquith Commission, that each Colonial university college should establish a relation with a specific university in Great Britain and work for the degrees of that university until it reaches university status and grants its own degrees, would have facilitated the maintenance of high standards and greater flexibility in the arrangements needed in these early years; in particular, two-way traffic and a wider distribution of Colonial students in British universities would have been possible.

Tree Root Development on Upland Heaths

The planting of heathlands with trees has always proved a tempting subject to the forester on the Continent of Europe as well as in Great Britain. Some research work at the instance of the Forestry Commission, especially in connexion with the rooting of coniferous trees on upland heaths, was carried out between November 1951 and April 1953, at selected forest areas in north-eastern England and Scotland, and has now been described by C. W. Yeatman in Forestry Commission Bulletin No. 21, "Tree Root Development on Upland Heaths" (pp. 72+24 plates and diagrams. London: H.M.S.O., 1955; 1*s*. 6*d*. net). There are considerable areas of this type of land available in Britain. The object of the investigation was to determine: the relationships existing between the development of the root systems, the soils, and the types and intensities of cultivation prior

to planting; the effects of the application of fertilizers on the vigour of the root systems; differences occurring in the root systems of the species studied; and the comparative ability of the root systems of these species to exploit the soil both in their natural state and when cultivated. An upland heath has been defined as "A Callunetum on shallow peat in which the roots of the vascular plants penetrate into the sub-peat layer". The peat is commonly two to four inches thick. Notes are given on the distribution of these heaths and the methods used, the findings, and the conclusions of an investigation into the root development of the principal conifers used extensively by the Forestry Commission in the north of England, such as Japanese larch, Scots pine, Sitka spruce, lodgepole pine and Corsican pine.

Systematics Association: Meeting in Edinburgh

A meeting of the Systematics Association was held at the Royal Botanic Garden, Edinburgh, during September 16–17. The three sessions were devoted respectively to the criteria of species, genera and families. Each session had a single main paper followed by general discussion, the principal speakers being Prof. I. Manton (species), Prof. T. G. Tutin (genera) and Mr. E. J. H. Corner (families). The meeting took its lead from the very beautiful electron micrographs of minute structure in the flagellate *Chrysochromulina* shown by Prof. Manton, and the prime necessity for accurate and detailed factual knowledge was emphasized at all three discussions. Two other themes also recurred: first, the difficulty of incorporating new types of data into the classification unless such data cover the whole geographical and taxonomic range of the unit under study; secondly, the need for continued availability of the old categories in an aggregate sense, even when research has shown their subdivision to be necessary in critical work. The meeting terminated with a visit to the new establishment of the Scottish Society for Research in Plant Breeding.

Among those attending the meeting were students from a vacation course in practical taxonomy which had just been given in the University Department of Botany at Edinburgh, and Dr. P. H. Davis outlined the scope of this course during an informal soirée on the Friday evening. Following lectures on some important aspects of herbarium work, the students had been set to revise small groups of Mediterranean species. The course made full use of the excellent herbarium and library facilities at Edinburgh, and was intended to fill a gap which must often arise in botanical teaching elsewhere.

Bibliographical Survey of Flexure Devices

The British Scientific Instrument Research Association has started to publish a series of bibliographical surveys on instrument parts, and the first of this series is entitled "Flexure Devices", by P. J. Geary (pp. 44; from the Association at Chislehurst, Kent; 1955; 10*s*. 6*d*.). It is a booklet comprising an illustrated technical introduction, digests of twenty-eight selected texts of major importance, an annotated list of one hundred and eleven references to texts of secondary importance, supplementary references and a name index. The period covered by the survey is from 1900 to the present. Periodical, book and report literature has been searched methodically, but not patent literature, although digests of some patent specifications have been included. No claim is made to complete coverage. Flexure devices take many forms, and for the purpose of the survey they have been grouped under the six headings: flexure pivots, parallel movements, twin strip mechanisms, buckling strip devices, rolling suspensions and the sine spring. These are described in some detail in the technical introduction, and their advantages and limitations are mentioned. Reference is made to the general use of flexible strips in gauging instruments following their introduction in about 1916 by the Metrology Department (now Division) of the National Physical Laboratory, Teddington, and to the forthcoming useful review, "The Application of Spring Strips to Instrument Design," to be published in the series of "Notes on Applied Science" of the National Physical Laboratory. The sine spring, a resilient member of adjustable stiffness, has been developed and applied by the Ministry of Supply.

National Foundation for Scientific Research, Brussels: Annual Report

The twenty-seventh annual report of the National Foundation for Scientific Research, Brussels (pp. 227; from the Foundation), covers the year 1953–54 and records a fourth grant, of 1,671,000 francs, to the Commission for Clinical Research. Of this, 350,000 francs went to the University of Ghent, 520,000 francs to the University of Liège, 345,000 francs to the University of Brussels, and 456,000 francs to the Catholic University of Louvain, chiefly for work on cortisone and the adrenocorticotropic hormone; lists of publications are appended to brief reports from each of these centres. Special grants made during the year include 200,000 francs for research on a scientific method of determining the mechanical characteristics of hydraulic cement; 250,000 francs for investigations on the physiology and pharmacology of the pulmonary circulation; and 750,000 francs for work on calculating machines in the university laboratories. Brief notes on the work on the utilization of radioisotopes at the Universities of Brussels, Ghent, Liège and Louvain, at the State Agronomic Institute at Gembloux, as well as in industry, are included. A further 2,000,000 francs was voted to the Interuniversity Microfilm Commission, and 100,000 francs for low-temperature research at the University of Louvain. Lists of recipients of grants for 1953–54 and of publications by recipients of grants during 1952–54 are appended.

Queen Victoria Museum and Art Gallery, Launceston, Tasmania: Annual Report

The annual report for 1953–54 of the Queen Victoria Museum and Art Gallery, Launceston, Tasmania (pp. 7; from the Museum; 1955), indicates progress in many directions. The vertebrate gallery has been reorganized, new displays have been completed in the new anthropological gallery, a new series of Tasmanian fossils has been placed on exhibition, the water-colour gallery has been re-hung, and photographic copies of certain paintings made available for art historians. The matter of public relations has been one for serious attention, and there is ample evidence in the report that the services provided by the Institution are appreciated by the community.

Classified List of Egyptian Scientific Papers

In 1952 the National Research Council of Egypt started to compile and issue annual lists of research papers published in Egypt and by Egyptians abroad. The third volume has recently appeared (pp. 127; from the Council, Cairo) covering papers published in

1953, and includes more university theses than the first two volumes. Entries are arranged by subject according to the Universal Decimal Classification and alphabetically by the names of authors; in this latest volume the rules used in the "World List of Scientific Periodicals" have been adopted for abbreviation of titles of periodicals. There are an author index and a supplementary list of Egyptian periodicals.

Science and Management: Conference in Harrogate

THE British Institute of Management will hold its national conference this year at Harrogate during November 2–4, the general theme being "The Impact of Science on Management in the Future". Among the subjects to be discussed are: training science and engineering graduates for industry; electronic processing of data; development of tools of production; operational research; the research associations; automation; human implications of technical innovation; use of radioactive isotopes; and training scientists for management. Stress will be laid throughout the Conference on the need to translate new scientific discoveries into immediate and practical day-to-day effect. Twenty-four sectional meetings will be held during the two full days of the conference; these will be arranged so that five or six will be held simultaneously, and, in effect, delegates will be able to attend five meetings altogether, at each of which there will be a choice of about half a dozen topics. On the evening of November 3 there will be a choice of sixteen discussion groups, each devoted to a topic currently attracting widespread attention in management circles. Altogether about a thousand persons will be attending the conference. The fee is £9. Further information can be obtained from the Institute at Management House, 8 Hill Street, London, W.1.

Fresh-water Biology in Scotland

A TWO-DAY meeting is being arranged for April 9–10, 1956, by the Institute of Biology (Scottish Branch), to be held in the Zoology Department of the University of Glasgow. There will be three half-days for papers and a half-day excursion to the University's Field Station at Rossdhu, Loch Lomond. The subjects will be: chemistry of fresh waters; plants as indicators of fish productivity; bottom fauna and bottom deposits; erosion products as affecting the river regime; fish parasites; molluscs; amphibia; trout; char; powan; pike; coastal migration of salmon; endocrines of salmonids; the work of the Salmon Inspectorate, that of the North of Scotland Hydro-Electric Board and that of the Brown Trout Research Laboratory, Faskally. Further information will be available in due course from Dr. R. M. Gorrie, "Balnagowan", Murrayfield Drive, Edinburgh, who is secretary of the Scottish Branch of the Institute of Biology.

Announcements

WE regret to record the death on September 29 of Prof. H. M. Turnbull, F.R.S., emeritus professor of morbid anatomy in the University of London, aged eighty.

PROF. P. M. S. BLACKETT, professor of physics, Imperial College of Science and Technology, London, and Mr. H. Douglass, general secretary of the Iron and Steel Trades Confederation, have been appointed members of the Advisory Council for Scientific and Industrial Research. Mr. J. Crawford, Prof. T. R. C. Fox and Sir George Thomson have retired from the Council on completion of their terms of office.

MR. STEPHEN CHEVELEY, chairman of the Central Agricultural Control, Imperial Chemical Industries, Ltd., has been appointed by the Minister of Agriculture, Fisheries and Food and the Secretary of State for Scotland to be chairman of the Governing Body of the Foot-and-Mouth Disease Research Institute, Pirbright, Surrey, in succession to Prof. Wilson Smith, who is retiring.

A CONFERENCE on "Raw Cotton—its Properties and Distribution" has been arranged by the Textile Institute and will be held in the Walker Art Gallery, Liverpool, on November 23. The speakers and their subjects are: Prof. S. C. Harland (University of Manchester) on genetics; E. Lord (British Cotton Industry Research Association) on cotton quality; Allan Draper (William Birtwistle Allied Mills, Ltd.) on spinners' requirements; and W. B. Hutchinson (Major Cleaver and Co.) on marketing. Further information can be obtained from the General Secretary, Textile Institute, 10 Blackfriars Street, Manchester 3.

A ONE-DAY symposium on chromatography will be held at Hatfield Technical College, Roe Green, Hatfield, Herts, on November 4. Four papers will be read, as follows: principles of chromatography (Dr. A. J. P. Martin), inorganic chromatography (Dr. F. H. Pollard), paper electrophoresis (Dr. A. B. Foster) and vapour-phase chromatography (H. N. Wilson). Tickets for the symposium are available on application to the College.

THE British Institute of Recorded Sound, in conjunction with the Department of Extra-Mural Studies of the University of London, has arranged for six lectures to be given by Mr. Eric Simms on "The Language of Birds and other Animals". The first lecture was given on October 4, and the others will be given on alternate Tuesdays (7 p.m.) at fortnightly intervals from that date. The fee is 10*s.* the course or 2*s.* 6*d.* each lecture. On January 25 at 7.30 p.m., Dr. W. H. George will give a lecture (fee 2*s.* 6*d.*) on "Pianists' Touch—its Scientific Study". All the lectures will be at the Institute premises, 38 Russell Square, London, W.C.1, whence further information can be obtained.

THE Department of Agriculture for Scotland has awarded the following postgraduate scholarships in husbandry, tenable for periods up to three years: A. D. Drysdale (University of Cambridge), Miss C. J. Falconer (University of Reading), David M. S. Livingston (University of Aberdeen and Low Temperature Research Station, Cambridge), R. A. N. Napier (University of Edinburgh) and Charles Smith (Iowa State College). In addition, the following current awards are being continued for a further period: I. C. Beattie, J. Frame and W. C. Smith (Massey Agricultural College, New Zealand), I. A. Munro (University of Reading) and T. M. Sutherland (Iowa State College).

THE Association of British Chemical Manufacturers (Cecil Chambers, 86 Strand, London, W.C.2) has recently published "British Chemicals and their Manufacturers, 1955" (pp. 192), which lists about twelve thousand products with the names and addresses of the manufacturers. The book is available free to persons or firms interested in the purchase of chemicals on application to the Association.

EDUCATION OF THE PHYSICIST

At the recent Bristol meeting of the British Association a recurrent theme in addresses to several sections was the specialist, and what should be done about him. Mr. J. F. Wolfenden, president of Section L (Education), spoke of the 'educated man' in 1955 as the man who could walk in the two great fields of thought, that of human aspirations and endeavour to which he would come through the humanities, and that of abstract thought and control over Nature to which man comes through science. Following him and speaking on the educated man in 1984, Dr. J. Bronowski threatened the world with Orwellian consequences if the schools and universities did not follow Mr. Wolfenden's advice; and Mr. Ritchie Calder, speaking as president of Section X (the Assembly of Corresponding Societies), accused scientists of knowing little in science itself outside each man's own speciality, and of being unable to achieve or communicate any broad picture of the state or meaning of science.

Mainly on this theme, a session on September 5 was organized jointly by Section A (Physics and Mathematics) and Section L (Education), devoted to the "Education of the Physicist", under the chairmanship of Mr. Wolfenden. The aims of the organizers were these: schools in Britain are frequently accused of over-specialization; Is this accusation just? Would anyone defend the present state of affairs? If the education of scientists is too specialized, where must we look for the remedy—to the schools or the universities? And would any remedies that might be suggested increase or decrease the number of boys who choose science? Finally, how, if at all, can we produce Mr. Wolfenden's educated man, the man who is equally at home in the humanities and in science?

The first speaker was Sir Philip Morris, vice-chancellor of the University of Bristol, who said that the central problem in education is the impact of the great increase in knowledge, particularly scientific knowledge, and its vastly increased importance. He feels that our primary education is notably successful, but that the secondary stage is the heart of our educational problem to-day. The idea of secondary education for all has caught men's imagination, as something we want and ought to have, but ideas as to what this education ought to be are shadowy, lacking coherent form and definite substance.

Interest in physics and the desire to make a career in the subject, or indeed in any other branch of science, normally show themselves during the secondary stage of a school education. The choice that a boy will make is partly a matter of natural aptitude, but partly a matter of the opportunities presented to him at school and the influences brought to bear on him. Sir Philip strongly emphasized how great is the influence of the secondary school, whether deliberate or not, in shaping the lives of the children who go there and in guiding them towards careers. He therefore thinks that a balance between the linguistic, the mathematical and the scientific is of the greatest importance during the first five years of the secondary school course, so that a child will have every opportunity to follow where his true abilities and ambition lie.

Sir Philip thinks that we have deviated more from a properly balanced education than we ought in these first five years. The problems that physicists in particular ought to ask themselves are: How vital is mathematical knowledge to the school child's appreciation of science? And should the sciences at this stage be taught as separate subjects? It is of the utmost importance that every secondary school pupil should learn about the scientist's outlook on the physical universe; Sir Philip placed this aim above, though not necessarily in opposition to, a preliminary grounding in particular scientific subjects.

In the last two or three years before the university, particular subjects chosen from those found in them must be followed seriously and deeply, but even so the course must have some balance. Much has been written on the educative value of a purely scientific education, and certainly really imaginative teachers can use science to provide for their pupils a full range of spiritual, emotional, social and political experience. But Sir Philip doubts the wisdom of making the attempt, and feels it better that science teachers should do their best to persuade their pupils of the importance of subjects outside their speciality and should leave it to others to teach these subjects.

Prof. N. F. Mott, Cavendish professor of physics in the University of Cambridge, spoke of his experience in interviewing candidates for admission to the University of Bristol when he was head of the Physics Department there, and the number of students who had said that, apart from their specialist studies, their curriculum included as little as one period of scripture, one of English, one of civics and one of gymnastics. Whether or not this was a fair description of the curriculum in many schools, it seems to him to indicate that in the boys' minds the subjects outside their specialization are treated with little respect. He believes that at least one arts subject, such as a modern language, should be continued seriously until the end of their time in the sixth form; and he believes that the sixth form rather than the university is the place where the basis of a general education should be laid. To widen the curriculum there would have two advantages. It would narrow the widely deplored gap between scientists and arts men, and it would defer the moment in a child's life when he has to choose between science and other subjects.

Prof. Mott then went on to discuss ways in which the universities could help the schools to widen the sixth form education with these ends in view. One way is to provide a means of entry into science faculties for those who have not specialized or have specialized late. Such opportunities already exist in the form of the Intermediate course, but Prof. Mott sees the possibility of an ambitious university, in co-operation with the Ministry of Education, founding a strong Intermediate course as the basis of a four-year course of study. He said he would like to see an increased emphasis on the 'General Paper' in scholarship examinations, and a renewed assurance given to the schools that this paper would be given a big role in awarding scholarships at Oxford and Cambridge. Another possibility is that a group of colleges would give an assurance that they would

offer each year a certain number of mixed scholarships in which a candidate would take both arts and science subjects. Such scholarships do exist at Cambridge, but few candidates of high quality enter for them; nor, he thought, would the schools attempt this kind of education, unless they knew that scholarships would be reserved for candidates of this kind.

Another possibility might be that a group of colleges could set a qualifying examination, say one year before the entrance scholarship examination, in an arts subject. It would not be compulsory, but candidates who passed it would have a certain percentage of scholarships reserved for them. They would take the same papers in science as the specialists, but would not be in competition with them.

Prof. Mott felt that the right solution could best be obtained by a given university or college working in co-operation with a group of schools, rather than by experiments on a national scale.

Prof. F. A. Vick, head of the Department of Physics of the University College of North Staffordshire, agreed with Sir Philip Morris that courses in physics can be designed which contain everything that a complete education should have, and he went further than Sir Philip in believing that they should be so designed. He believes that they should teach a good fundamental knowledge of the subject and at the same time develop insight and imagination—as important in the physical sciences as in any other creative activity of the human mind—intellectual courage and honesty, understanding of scientific proof, ability to assess a situation, logical thought, clarity and precision of expression, experimental skill, ability to handle abstract ideas, judgment, recognition of the limitations of science, and humility in face of the wonders and mysteries of Nature.

An interesting suggestion brought out in Prof. Vick's paper was that he would advocate founding in some university a school which would stand alongside the Oxford 'Greats' and 'Modern Greats', and which would contain physics as a major component. Philosophy, physics and economics might be combined in such a course—P. P*. E. he called it. As a firm believer in the educational value of physics, he thinks that such a course would admirably equip the politicians, Civil servants and industrialists of the modern world. Prof. Vick's experience in teaching physics to arts students in courses lasting one or two sessions at the University College of North Staffordshire has convinced him that some of them become very interested in the subject, and are prepared to work hard in it, even if they would not wish to become professional physicists, and that they would be capable of doing well in a P. P*. E. combination. Even with the comparatively short courses at subsidiary level, the potential barrier which so often exists between an arts man and any science is penetrated or broken down. The whole outlook of the student is broadened.

Dr. A. W. Barton, headmaster of the City of London School, maintained in agreement with the other speakers that the school is just as important as the university; in particular, it has to choose the future scientists. He told how this is done at the City of London School. In the last resort, the choice is made by the boy and his parents; but Dr. Barton was emphatic that, in view of the needs of the community, the school would be right to lay strongly before a boy the advantages of a scientific career.

Dr. Barton does not think that the average physicist specializes too much at school. In the first four years he will spend two-thirds of his time on the humanities, and in the last three years one-third or one-quarter; and he does not think that Prof. Mott's "one period each of scripture, English, gym. and civics" is typical. Moreover, he believes that the sixth-form education is more liberal than it was forty years ago. Neither does he think that the competitive nature of the Oxford and Cambridge entrance scholarship leads to excessive specialization. The questions now set test no more ground than they did thirty-nine years ago. He thinks that the potential scholar is quite capable of answering these papers without being unduly pressed and without spending more than a reasonable time on science. It may well be that some pupils are over-specializing in the attempt to reach the standard of these papers; but that is not the fault of the papers, but of the schools in trying to prepare unsuitable pupils for them, and will soon disappear now as local authorities give reasonable assistance to potential physicists to go to the university even if they are well below the standard of an open scholarship.

BRITISH SEISMOLOGY DURING 1954–55

THE sixtieth annual report of the Committee for Seismological Investigations appointed by the British Association, covering the work done by British seismologists during the year 1954–55, was presented to Section A (Physics and Mathematics) of the Association at its recent Bristol meeting. As part of the work carried out in the Department of Geodesy and Geophysics at Cambridge, Dr. M. N. Hill has continued his seismic refraction-shooting experiments in the English Channel and the Western Approaches. From the results obtained at a line of stations extending down the middle of the English Channel from the Greenwich meridian to the longitude of Weymouth, it was found that the depth to the palæozoic floor varied between 2,400 and 3,500 ft. These figures are smaller than had been expected by Dr. Hill. Dr. R. Stoneley has investigated the problem of the propagation of surface waves in a medium with cubic symmetry, the free surface of which is a principal plane. The propagation of waves of Rayleigh type is not possible for all values of the density and the three elastic constants; but when it is possible, the wave velocity depends on the direction of propagation. For the symmetrical cases of transmission along a principal axis, or along a bisector of two perpendicular principal axes in the free surface, Rayleigh wave-motion can occur, in which the particles describe ellipses in a retrograde direction. In these cases only can transverse motion (as in Love waves) exist by itself. In the general case the plane of the particles is inclined to the plane of propagation; in fact, the separation in an isotropic solid into Rayleigh waves and transverse motion occurs as a mathematically degenerate case of this general type of motion.

At the University of Durham Observatory, the building of an underground chamber for the seismographs has begun, and it is estimated that, when completed, the diurnal temperature variation in it will not exceed 1 deg. F. The director, Mr. E. F. Baxter, hopes shortly to be in possession of a Wilson–Lamison vertical seismometer to complete a set of

instruments, the Observatory being equipped at present with two horizontal Milne–Shaw seismographs. The two earth tremors felt at Hemsworth and South Elmsall in south Yorkshire on October 23, 1954 (see *Nature*, 175, 587; 1955), have also been investigated by Mr. Baxter. The first was recorded at Durham, at Kew and at Rathfarnham near Dublin, though not at Edinburgh. From an analysis of the seismograms, Mr. Baxter has determined the epicentre at lat. 53° 36′ N., long. 01° 19′ W., and time of origin 13h. 26m. 10s. G.M.T. The strength of the shock macroseismically was III on the Modified Mercalli scale.

At the National Institute of Oceanography, Mr. J. Darbyshire has calculated refraction diagrams for microseismic waves approaching Bermuda on the assumption that they are surface waves between the ocean and the sea-bed of the type described by Stoneley. The diagrams show that the refraction of energy away from the island is very marked for waves approaching from the north-east and south-west. This effect explains some of the anomalies observed at Bermuda, in one of which a storm slightly to the west of north gave large microseisms, whereas one slightly to the east of north had little effect. The work shows that the study of recordings at islands must take account of refraction.

International co-operation is most important in seismology as in other sciences and, apart from private research and personal contacts, British seismologists have been recently active with the loan of instruments (a new driving clock has been ordered for the instrument at Suva, Fiji, with money from the Gray–Milne Fund), through the International Seismological Summary, and through attendance at the tenth General Assembly of the International Union of Geodesy and Geophysics in Rome during September 14–25, 1954. The International Seismological Summary is under the direction of Sir Harold Jeffreys, the calculations being done at Kew by Mr. J. S. Hughes and his staff. The work for June 1947 is in hand, the first five months of the year being ready for printing. The third quarter for 1946 will be distributed shortly. Dr. Stoneley reports that the programme of the General Assembly of the International Union of Geodesy and Geophysics was a very full one and was notable for the number of interesting and successful symposia and joint meetings of associations. For the first time since the Second World War, Soviet geophysicists were present, attending by invitation; in particular, the names of Prof. Vladimir Beloussov, of the Moscow Academy of Sciences, and Prof. Georgy Gorshkov, of the Moscow State University, may be mentioned. The Assembly was preceded by a reunion of the European Seismological Commission, under the presidency of Prof. W. Hiller. The proceedings of the Association of Seismology and the Physics of the Earth's Interior opened with a presidential address by Prof. B. Gutenberg on "The Effects of Low-Velocity Layers", and some of the joint meetings held were as follows: constitution of the Earth and dissipation of energy (with vulcanology); isostasy (with geodesy), and gravimetric and seismic interpretation; variation of latitude (with geodesy and vulcanology). In addition to special sessions on apparatus, on microseisms and on seismography, the grouping of papers under headings gave the meetings more of the character of symposia. The considerable development of seismology during recent years was evident.

Ernest Tillotson

ADVANCES IN MOLECULAR SPECTROSCOPY

MEETING IN OXFORD

THE European Molecular Spectroscopy Group, which was constituted informally after the Second World War and held meetings in Constance (1947), Basle (1951) and Paris (1953), met again this year, in Oxford, during July 7–11. This meeting was a great success, and thanks are due to the industrial firms whose financial help made it possible. Among two hundred and eighty participants were representatives from fourteen European countries, Brazil, the United States, Canada, South Africa and Japan. More than eighty papers were presented, covering many topics in ultra-violet, infra-red and Raman spectroscopy, with an emphasis on spectral theory and the correlation of spectra with molecular constitution and reactivity rather than on technique or analytical applications.

The ease with which spectra can now be photographed or recorded automatically has stimulated more attention to different conditions of excitation and to the physico-chemical factors which determine detailed spectral characteristics. For example, very interesting results are emerging from the study of infra-red absorption spectra of gaseous mixtures at high pressure, or of mixtures of liquids. B. Vodar (Bellevue, Paris) and his colleagues, using mixtures of hydrogen chloride and hydrogen at high pressure, have found an infra-red absorption band corresponding to ($\nu_{HCl} + \nu_{H_2}$), the combination of the active hydrogen chloride fundamental with the inactive vibration of hydrogen. Also, the absorption band due to ν_H, which becomes active at high pressures, is affected by hydrogen chloride or other added gases. Similarly, J. Fahrenfort (University of Amsterdam) has found that using compressed mixtures of carbon dioxide with nitrogen, oxygen or hydrogen, absorption bands are observed due to simultaneous transitions in a collision pair, such as ($\nu_{CO_2} + \nu_{N_2}$) or ($\nu_{CO_2} + \nu_H$); he has examined this effect in terms of the mutual molecular polarization and has found satisfactory agreement between the predicted and observed band intensities. All these measurements bear on the question of the formation of transient molecular complexes or aggregates, quite apart from the general information they may provide about intermolecular forces.

Analogous effects have been found for liquid mixtures by J. Ketelaar (University of Amsterdam). In thick layers, a carbon disulphide–bromine mixture shows bands at 1,807 cm.$^{-1}$ and 1,204 cm.$^{-1}$, lying respectively 306 cm.$^{-1}$ on either side of the strong absorption band of carbon disulphide at 1,510 cm.$^{-1}$. This displacement interval corresponds to the vibration frequency of bromine. When polyatomic molecules are mixed with carbon disulphide, an array of displaced bands is found, analogous to a vibrational Raman spectrum spread around the main carbon disulphide band at 1,510 cm.$^{-1}$. Thus we may not only detect collision complexes but also determine the low frequencies of a heavy molecule in a more convenient spectral region. H. L. Welsh (University of Toronto) described further work on the 'forbidden' infra-red bands of carbon dioxide and hydrogen in the liquid and solid states. At low temperatures these bands assume a more complex pattern in consequence of intermolecular inter-

actions and specific properties of the crystalline solids, and combination transitions of hydrogen–deuterium molecular complexes have also been observed.

The interpretation of vibrational band intensities, which are as significant as the frequencies, has progressed rapidly. These intensities are controlled by the polar characteristics of the vibrations concerned, and therefore lead to deductions about bond polar properties and the electronic structure of the whole molecule. Since, moreover, the creation during molecular vibration of centres of residual electrical charge may be a prelude to reactivity, the absorption band intensities may be correlated with the latter. True integrated absorption band intensities, as opposed to their 'apparent' values or the 'apparent' extinction coefficients, can now be determined with fair accuracy. Use of these data is limited, however, by uncertainties in the molecular force fields and by ambiguities which arise in part since the square root of the intensity has an indeterminate sign. One possible way out is to study a set of isotopic molecules where for a given vibration-type the derivative o electric moment with respect to a symmetry coordinate should be constant. B. L. Crawford (University of Minnesota) described such work on ethylene and the deutero-ethylenes, and on the methyl halides, D. F. Hornig (Brown University) on methyl cyanide and the cyanogen halides, and D. H. Whiffen (University of Birmingham) on benzene. It is noteworthy that in some of these structures, carbon–carbon bonds are found to have fairly large dipole moments.

S. Silverman (Johns Hopkins University) has determined the integrated band intensities of hydrogen halides and carbon monoxide from measurements on individual rotation lines, and has analysed the results in terms of a new more detailed theory which assumes a more general expression for the variation of dipole moment with bond-length and which also considers vibration–rotation interaction. Theoretical work on the band intensities of hydrogen halides was also discussed by S. Penner (California Institute of Technology, Pasadena).

The function expressing variation of a bond dipole with change in length, $M = M_0 + M_1\xi + M_2\xi^2 + \ldots$, has assumed greater interest since it is now realized that most vibrations involve considerable electrical anharmonicity, expressed by the quadratic and higher terms in ξ, and this determines the overtone intensities more than mechanical anharmonicity. H. W. Thompson and D. W. Russell (Physical Chemistry Laboratory, Oxford) described work on the bands ν_{NH} and $2\nu_{NH}$ of a selected series of complex organic molecules including aliphatic and aromatic secondary amines, amides and heterocyclic bases, from which the coefficients M_1, M_2, can be derived and correlated with variations of ionic character in the different kinds of NH bond.

Attempts have been made to correlate the variation of vibration frequency of a key group in a related series of molecules with changes in reactivity. L. J. Bellamy (Waltham Abbey) discussed further examples of substituted benzenes in which a relation exists between a particular vibration frequency and the Hammett σ-factor for the particular substituent. Such relations might be applied to estimate dissociation constants of acids and bases, redox potentials, etc., although there are some anomalies and the frequency variations are often small. Any inductive or mesomeric effects will be similarly reflected in the bond polar properties, and the consequential variation of band intensities may be more pronounced than the frequency shifts. Thus, H. W. Thompson showed that for the C≡N bond vibration in substituted benzonitriles there is a proportionality between log (intensity) and σ over a wide range, and similar correlations between the intensity and several reaction constants. A striking difference of intensity of ν_{CN} in the solvent carbon tetrachloride or chloroform was noticed in cases where hydrogen bonding of chloroform to the solute could occur favourably, which emphasizes the need for care where quantitative analysis is being carried out in apparently innocuous solvents. The intensities of NH-group vibration bands in platinum-amine complexes have also been correlated with electronic structure by L. A. Duncanson (Imperial Chemical Industries, Ltd., Welwyn); and G. Higgins (British Rubber Producers' Research Association, Welwyn) described how infrared studies of the association equilibria between organic hydroperoxides, phenols or alcohols with dialkyl sulphoxides may be used to estimate the dissociation constants of weak acids.

Higher resolving-power in the infra-red, obtained with better detectors and gratings, is being used to obtain further details of molecular dynamics. Fermi resonance between vibrational levels often leads to anomalous values in the coefficients α_i relating the rotational constants in different vibrational states, and also in the centrifugal stretching-constants D_i. More accurate values can also be obtained for the Coriolis coupling factors ζ_i and l-doubling coefficients in degenerate vibrational levels. Such work on carbon dioxide, nitrous oxide and allene was described by H. H. Nielsen (Ohio State University), on some hydrides of the fourth-group elements by M. Kent Wilson (King's College, London), and on acetylene, methyl acetylene, hydrogen cyanide and their deuterium analogues by H. W. Thompson. A further revision of the bond-lengths in acetylene seems necessary. W. F. Edgell (Purdue University) explained a new method whereby the measurement of vibrational band contours promises to yield values for the molecular rotational constants.

Many papers were concerned with general infrared developments and vibrational analysis. L. Genzel (University of Frankfurt) described a new grating spectrometer for use to 1,000μ, using a high-pressure mercury arc as source with suitable filters. R. C. Lord (Massachusetts Institute of Technology) and his colleagues have found from the spectra of *cyclo*butane and *cyclo*propane and of their deutero analogues that the former appears to contain a puckered ring, and in the latter $r_{cc} = 1524$ A. R. Mecke (University of Freiburg) has measured the spectra of homologous series of $\alpha\omega$-dibromoparaffins and alkyl bromides in the liquid and solid phases. In the solids, rotational isomerism is excluded, and by considering the whole series a reasonable assignment of the carbon-chain vibrations can be made. S. F. D. Orr (Chester Beatty Research Institute, London) has found that in *trans* stilbenes, although the integrated intensity of the nonplanar =C–H deformation is unaffected by *ortho* substituents, the band-width and peak extinction coefficients are much affected, and an explanation in terms of vibrational damping is suggested. N. Sheppard (Laboratory of Colloid Science, Cambridge) has assigned the vibration frequencies of the guanidinium ion, $C(NH_2)^+_3$, in crystals and solid films, and data relevant to the study of ureas and amides. Mlle. M. L. Josien

(University of Bordeaux) and colleagues have measured ν_{CO} in ketones and in quinones of mono- and poly-nuclear aromatics, while N. Fuson (Fisk University) has studied substituted benzanthracenes of carcinogenic interest. The assignment of OH-group vibrations in enolized diketones and ketonic alcohols has been explored by D. Hadzi (University of Ljubljana) and by C. Duculot (University of Paris), and W. Lüttke (University of Freiburg) has studied the dimerization of nitroso compounds.

A packed session of the meeting, on the infra-red spectra of amides, peptides and polymers, served to emphasize the difficult stage which this work has reached, and the hazards of interpreting spectra with polarized radiation. G. B. B. M. Sutherland (University of Michigan) suggested that analysis in terms of group frequencies can only provide a partial interpretation. With crystalline polymers, in which a structural unit is visualized in the unit cell, appropriately influenced by its environment, more exact selection rules will apply than with liquid or amorphous polymers. He illustrated this argument by reference to polyethylene, ice and other substances. From results with crystals of naphthalene, iodoform and thiourea, R. M. Hexter (Cornell University) claimed to verify a point made several years ago, but not sufficiently appreciated, that transition moments of vibrations are often not parallel or perpendicular to bond directions; and he suggested that if dichroic ratios are to be correctly determined the complete anisotropy must be measured. A. Elliott (Courtaulds, Ltd.) has found that with crystals of acetanilide the transition moment of the carbonyl group is inclined to the bond direction.

E. K. Blout (Polaroid Corporation) observed that, whereas lower members of a series of polybenzyl glutamates have $\nu_{CO} = 1{,}628$ cm.$^{-1}$, the higher members have $\nu_{CO} = 1{,}655$ cm.$^{-1}$, in line with β- and α-configurations of polypeptides; and he suggested that some previous discrepancies between different laboratories might arise from degradation of polymers during the casting of films from solvents. H. A. Willis and R. G. J. Miller (Plastics Division, Imperial Chemical Industries, Ltd.) proposed a method for determining the crystalline–amorphous content of polymers such as polyethylene or polyethylene terephthalate, based only upon the broad bands of the amorphous form which are associated with the multiplicity of rotational isomers; J. Mann and J. Marrinan (British Rayon Research Association) showed how the hydroxyl group bands in different crystalline forms of cellulose can be used to characterize the latter; the old problem of the 'amide group' bands in the gaseous, liquid and crystalline state was reconsidered by S. Mizushima (University of Tokyo) and by M. Davies (Aberystwyth); and D. S. Barmby (Wool Industries Research Association, Leeds) outlined the effect on key bands of nylon when it is dissolved in antimony trichloride—a possible start to the study of the swelling of polymers.

As regards theoretical aspects, C. A. Coulson (Mathematical Institute, Oxford) showed how data on the lengths of carbon–carbon bonds can now be systematized in terms of specific types of hybridization and hyperconjugation. J. W. Linnett (Inorganic Chemistry Laboratory, Oxford), in reviewing possible ways of assessing molecular force fields, suggested that more use might be made of isotopic effects other than with hydrogen–deuterium, and that the Coriolis factors ζ_t and centrifugal stretching constants D^t mentioned previously may also be useful. New methods were outlined by P. W. Higgs (Mathematical Physics Department, Edinburgh) for calculating the vibration frequencies of complex molecules, and by H. Günthard (Federal Technical Institute, Zurich) for obtaining relations between the intensities of bands of isotopic molecules, while G. Amat (P.C.B., Paris) considered the effects of Fermi resonance upon molecular rotational and vibrational energy-levels in detail. P. Tuomikowski (University of Helsinki) described comparative studies of Fermi resonance for a given molecule in different states of aggregation.

Raman spectra of coloured substances, using red or near infra-red radiation as the exciting source, were described by H. Stammreich (University of São Paulo); discharge lamps of helium, rubidium or cæsium were used, and the substances studied included bromine, iodine chloride, iodoform and polyhalide ions. Raman spectroscopy of gases with high resolution, using multi-reflexion cells and high-current water-cooled mercury arcs, is advancing rapidly, and H. L. Welsh (University of Toronto) gave new data on vibration-rotation bands of a number of simple hydrocarbons. This method not only provides information about certain bands not obtainable in the infra-red, but also the confusing influence of 'hot' bands is sometimes minimized. Several speakers discussed Raman spectra of crystals and complex ions, and on the basis of intensities of Raman bands in homologous series of ketones, esters and nitro compounds G. Michel (University of Liège) suggested that rules can be set up for analysis and structural diagnosis. D. A. Long (Physical Chemistry Laboratory, Oxford) discussed the more fundamental relationships between Raman band intensities and bond polarizabilities, with special reference to tetrahalides and related structures. Progress here runs parallel to that already mentioned in which infra-red band intensities are being correlated with bond polar properties.

W. C. Price (King's College, London), B. Vodar (Bellevue, Paris) and A. D. Walsh (University of Leeds) discussed technical advances in the vacuum ultra-violet and the correlation of absorption spectra with molecular ionization potentials. Improved emission sources and continuous photoelectric recording should lead to further progress in this field. H. Schüler (Hechingen) has obtained evidence for the ultra-violet emission spectra of benzyl and benzal radicals produced in the positive column of a glow discharge in vapours of certain benzene derivatives—an experimental method which may provide many data on the emission spectra of polyatomic molecules. The absorption spectra of such radicals have also been measured by G. Porter (British Rayon Research Association) after 'trapping' radicals formed by flash photolysis in a rigid medium where they persist for long periods in metastable equilibrium. This trick of retaining simple polyatomic radicals in solid matrices was also described by G. Pimentel (University of California). The use of crystals of aromatic compounds at very low temperatures has also enabled P. Pesteil (Sorbonne, Paris) to obtain sharper fluorescence spectra ($T \rightarrow S$) and to determine many molecular vibrational levels. Other ultra-violet studies included the exciton spectra in inorganic crystals at low temperature (S. Nikitine, University of Strasbourg); the effect of substituents on the spectra of diphenyls and benzophenones (G. H. Beaven, National Institute for Medical Research, Mill Hill, and R. F. Rekker, Free University of Amsterdam); the spectra of benziminazoles and

thiophenes; and many new spectra of diatomic oxides, halides and diatomic ions which extend general theories of molecular structures further. H. C. Longuet-Higgins (Chemistry Laboratory, Cambridge) analysed theoretically the electron states of a composite system in relation to those of its constituent parts and showed how some general ideas about electron transfer configurations can be used in this connexion. R. S. Mulliken (University of Chicago) and C. J. Timmons (University of Nottingham) discussed charge transfer and charge resonance spectra and the correlation of spectra with intermolecular complex formation.

H. W. THOMPSON

PROGRESS IN RADIOBIOLOGY

CONFERENCE AT CAMBRIDGE

ON August 15, radiobiologists met in Cambridge for the third annual conference to discuss progress in their field. The three-day meeting, under the chairmanship of Sir Ernest Rock-Carling, was organized by Prof. J. S. Mitchell and his staff. Some 250 scientists, from sixteen countries including the U.S.S.R., enjoyed the hospitality of our Cambridge hosts. Eighty papers were discussed, the variety of the contributions reflecting the large number of disciplines on which an understanding of the biological effects of radiation must rest.

Biological lesions due to ionizing radiations must originate in the process of absorption of primary energy. Our current picture of the particle track, and relevant knowledge of the nature of the chemical intermediates, were presented by Prof. F. S. Dainton in an introductory lecture. A number of metabolic steps occur between the initial chemical disturbance and the appearance of damage in the organism, and some papers dealt with such effects. In the bacterium *Achromobacter fischeri*, the enzymatically controlled luminescence decreases during exposure to X-rays and recovers rapidly afterwards. Both decrease and increase follow an exponential time relationship (O. Hug and I. Wolf). Bacterial enzymes show a lower sensitivity to X-rays at low temperatures when exposed in the dry state or in solution, or when in the intact cell, suggesting some common physicochemical mechanism of inactivation (H. Pauly and B. Rajewsky). It appears, however, that in the etiology of the opacity of rabbit lens caused by X-rays, biochemical changes in the lens are secondary to cellular damage in the dividing cells of the lens epithelium (A. Pirie).

The genetic effects of radiation took a prominent place in the discussions. Nucleic acids appear to be the main carriers of hereditary factors, and some insight into the action of radiations on genetic material may be expected from the study of radiation effects on them and their metabolism. Some questions discussed were the effect of ultra-violet light on ribonucleic acid metabolism in starfish oocytes (M. Errera and A. Ficq), the inhibition of deoxyribonucleic acid (DNA) synthesis by X-rays in the early stages of regeneration of rat liver (L. K. Mee), and the interesting results obtained in the irradiation of dry preparations of herring sperm deoxyribonucleic acid (P. A. Alexander and K. A. Stacey). The sensitivity of female germ cells of mice to the induction by X-rays of dominant lethal mutations is some seventy times greater at first meiotic metaphase than at a stage seven hours earlier (L. B. Russell and W. L. Russell). In *Habrobracon* eggs irradiated with ultra-violet light, damage to the nucleus is qualitatively and quantitatively different from cytoplasmic damage (R. C. von Borstel and H. Moser). A surprising result was obtained when a breeding population of *Drosophila* was exposed to 5·1 r. per hr. for about five years. Its genetic fitness was only 1–5 per cent lower than that of an unirradiated population, despite an accumulated dose of 250,000 r. (B. Wallace). We are not justified, however, in extrapolating from insects to mammals on the basis of these data (W. L. Russell). Bacteria and bacteriophage have been used as a simplified model for the study of genetic changes in populations (H. Marcovitch).

Since certain chemicals and X-rays cause similar biological damage, it is of interest to study the mechanisms by which these lesions arise. A whole-body dose of 100 r. of X-rays, or 1 mgm. per kgm. of nitrogen mustard, produce the same damage in rat lymph nodes; but the treatments have dissimilar actions since they are not interchangeable (C. Biagini). N,N-dichlorethyl-*p*-amino-phenyl-butyric acid causes mainly lymphoid, whereas 'Myleran' causes mainly myeloid effects in rat bone marrow. The effect of X-rays can be reproduced almost exactly by applying both chemicals at once, suggesting two separate physiological pathways for the developing X-ray damage (L. A. Elson, D. A. G. Galton, L. F. Lamerton and M. Till).

Factors influencing the radiosensitivity of biological systems were discussed in almost every session. It has been known for some time that radiation effects are usually greater in the presence than in the absence of free oxygen. Tails of young mice were used to demonstrate this with X- and neutron-irradiation (P. Howard-Flanders; E. A. Wright). The rapid autoxidation of cysteine in aqueous solutions suggests that a number of protective effects ascribed to this compound could be accounted for by anoxia (L. H. Gray). Cysteine and cysteamine have a stimulating effect on the oxygen consumption of liver slices. Their protective effect may therefore be due to a reduction in the amount of free oxygen in some organs (D. W. van Bekkum). Chemical protection and anoxia do not, however, always seem to act along identical pathways (R. W. Brauer, J. S. Krebs and R. Pessotti; J. Maisin, P. Maldagne, A. Dunjic and H. Maisin). Further, cysteine and cysteamine react with the sulphhydryl group of proteins and might thus protect the protein (L. Eldjarn and A. Pihl; R. Koch).

The effects of oxygen on radiosensitivity may be explained in terms of the relative efficiencies of oxidizing and reducing radicals in reacting with organic molecules, although the state of oxidation of the acceptor substances is of importance (A. J. Swallow; M. Ebert and A. Howard; H. Laser).

The radiosensitivity of barley seeds and of starch depends on humidity, and is at a minimum at 20 per cent. It was suggested that the cause is physicochemical rather than physiological (L. Ehrenberg). The production of chromosome aberrations in *Vicia faba* roots by 8-ethoxycaffeine or X-rays is sensitive to oxygen, but adenosine triphosphate appears to be involved only in the case of the caffeine (B. A. Kihlman). Other work on *Vicia* indicates that inhibition of oxidative phosphorylation interferes with the rejoining of broken chromosomes (S. Wolff).

It is well established that shielding of hæmopoietic tissue, or implantation of such tissue after irradiation,

greatly improves the recovery of animals from acute radiation injury. It seems likely that the implanted cells are fully effective only if not destroyed by tissue antibodies (D. M. H. Barnes and J. F. Loutit). Spleen irradiated *in vitro* or taken from an irradiated donor can resume hæmopoiesis in the host even after a dose of 10,000 r. (E. H. Betz, G. Booz and J. Firket), and the spleen of an irradiated animal recovers more quickly if part of its bone marrow is shielded (E. H. Belcher, E. B. Harris and L. F. Lamerton).

The carcinogenic effect of a given dose of whole-body X-irradiation is approximately the same whether given in daily, weekly or fortnightly fractions, but is less effective when delivered in one exposure, as judged by the appearance of leukæmia in mice (R. H. Mole). Beta-radiation applied to the skin of rats produces more tumours when given in two exposures than in one (J. W. Boag and A. Glücksmann). Glass beads containing strontium-90 produce tumours at the site of implantation under the skin of rats, and the incidence of tumours is proportional to the logarithm of the radioactivity (G. Schubert, H. A. Künkel and G. Uhlmann). Rats of a tumour-free strain, protected by cysteamine or part-shielding against the acute effects of X-irradiation, develop a variety of tumours if they survive more than six months (Maisin *et al.*). Therapeutic irradiation for ankylosing spondylitis appears to be followed by a five- to ten-fold increase in the rate of deaths from leukæmia (W. M. Court-Brown).

For those who attended the previous conferences (Aarhus, 1953, Liège, 1954), several points of increased emphasis became apparent at this meeting. They included more widely based inquiries into the mechanism of action of protective agents, the long-term carcinogenic effects of radiation, and the search for biochemical links in the developing radiation-induced lesion.

M. Ebert
A. Howard

NEW NATURE RESERVES IN GREAT BRITAIN

THE Nature Conservancy has announced the establishment of five new nature reserves, three in England and two in Scotland, as follows: Roudsea Wood, Lancashire (ten miles west of Grange-over-Sands); Wybunbury Moss, Cheshire (three and a half miles south of Crewe); North Fen, Lancashire (two miles west of Windermere); Hermaness, Unst, Shetland; and Noss, Shetland. The Conservancy has also announced the addition of areas to the following two existing reserves: Castor Hanglands, Northants (four and a half miles north-west of Peterborough); and Kingley Vale, Sussex (four miles north-west of Chichester).

Roudsea Wood is one of the most varied woodlands in the British Isles, with a rich flora and fauna and many different types of vegetation. It lies in the south of the Lake District and is the first nature reserve to be declared within an English national park. The reserve, which has been formed by agreement with the owner, Mr. R. E. O. Cavendish, covers an area of 287 acres and is about ten miles west of the Conservancy's Research Station at Merlewood, Grange-over-Sands, Lancashire. The main part of the wood consists of two parallel ridges, one of limestone and one of slate. The limestone ridge is crowned by a yew wood and has interesting mixtures of oak and ash on its flanks with a luxuriant ground flora, including lilies-of-the-valley. The slate ridge, on the other hand, is a typical Lake District slate oak-wood which has, in part, been coppiced for charcoal production. Between ridges there is a small tarn, now nearly filled, and around it an abundance of fen plants and fen insects. Among these is a sedge (*Carex flava*) for which this is the only British locality. There are a wealth of sloe, alder, birch and other shrubs, and a correspondingly great variety of insect and bird life.

On its seaward side, Roudsea Wood slopes down into the Morecambe Bay salt-marshes, this being one of the few places where the transition from salt-marsh to woodland can be studied. On the landward side lie the Holker mosses, and the transition from the vegetation of peat to that of limestone and slate is also of very great biological interest. In addition to the usual plants and insects, there are roe-deer, occasional fallow and red deer, and a great variety of wild-life of every kind. One of the main objects of this reserve is to serve as an undisturbed outdoor laboratory for the scientific workers at Merlewood, who have already begun their investigations, and applications for permits to visit the reserve for research or collecting purposes should be made to the Conservancy's regional officer at Merlewood.

Wybunbury Moss in South Cheshire is an unusually large example of a 'Schwingmoor', a type of bog not before described in Britain. It has been formed in a steep-sided kettle-hole in sandy, glacial material, the sides of which are cultivated and used for grazing. Only part of the land has been declared a reserve, and it is hoped to extend the area in the future. At the centre of the bog there is only a thin crust of sphagnum peat 6–10 ft. deep floating on water, but at the margin deposits of both sphagnum and fen peat have accumulated to form a solid organic layer over the glacial sand. The surface vegetation shows a surprising variety for such a small area. The margins, which must receive a mineral supply from the cultivated sides of the kettle-hole, carry a fen community with sedges such as *Carex paniculata*, but this fen is a secondary development because it is underlain everywhere by sphagnum peat. As a marked contrast, the central area shows a typical bog flora carpeted with sphagnum species in which cross-leaved heath (*Erica tetralix*), cranberry (*Oxycoccus palustris*) and marsh andromeda (*Andromeda polifolia*) are common. The ground is gradually becoming drier as part of the natural development, and, as this occurs, trees, mainly birch and scots pine, are spreading. The reserve will be used solely for scientific research, and permission to visit it can only be obtained through the Conservancy's officer at Merlewood.

The main interest of North Fen is that it shows the vegetational succession characteristic of the climatic conditions found in north-western England—open water, rich in mineral salts, to fen-carr and bog. It is mainly woodland and is only just beginning to show signs of sphagnum bog development, in contrast to the nearby Blelham Bog reserve, where there is very little left of the original woodland. The reserve lies on the north side of Esthwaite Water in the Lake District National Park and is being established under a lease from the National Trust. The vegetational succession in North Fen is reedswamp (*Phragmites communis* dominant, with *Scirpus lacustris* on the offshore margin), mixed fen (predominantly a sedge association with *Carex elata* and *Carex rostrata* conspicuous), open carr followed by closed carr (dominated by *Salix atrocinerea*). Some modification of this succession occurs, particularly on the western

and eastern flanks of the fen as the result of a difference in the rate of inorganic silting. It appears that, in north-west England, fen communities are only developed where substantial inorganic sedimentation occurs. Such communities are of a purely transitional nature, eventually giving way to bog as the organic/inorganic ratio of the substrate increases. Access to the reserve will not be restricted, but to collect specimens permission is needed from the Conservancy's officer at Merlewood.

Muckle Flugga and the Outstack, the northernmost of all the British Isles, are included in the new nature reserve of Hermaness, which is closer to the north pole than the southern tip of Greenland. Hermaness itself is a peninsula on the north-west of the Island of Unst, Shetland, and carries rough moorland with blanket bog on gneiss; there are many lochans and several miles of high sea-cliffs. The size of the reserve is 1,071 acres, all but 31 being on the mainland. The scientific interest of the reserve is mainly ornithological, in particular as an important breeding-station of the great skua, a bird with a very restricted distribution in the northern hemisphere but also breeding in the Antarctic. An ancestor of the present proprietor, Lieut.-Colonel Laurence Edmonston, was responsible for protecting the great skuas on Hermaness: in 1850 there were only two pairs; by 1890 there were not more than nine pairs; later the increase there and elsewhere was rapid; and to-day there are about five hundred pairs nesting on the reserve. In addition, the species has spread to other parts of Shetland and to the Orkney Isles. Besides great skuas, numbers of arctic skuas, red-throated divers, eider duck and arctic terns breed on the peninsula. The sea-cliffs contain an expanding gannetry and also colonies of guillemots, razorbills, kittiwakes, puffins, storm petrels and other birds. There is a watcher's hut on the slopes of Hermaness Hill. The Royal Society for the Protection of Birds will continue to provide a warden, as before.

With its great cliffs, Noss is one of the most spectacular islands in Europe. Divided from the mainland of Shetland by the larger island of Bressay, Noss Head rises to 592 ft., and the uninhabited island extends to 774 acres, mainly of rough moorland. On the cliffs there are many nesting gannets, guillemots, shags, kittiwakes, puffins, greater black-headed gulls and herring gulls. On the moorland there are colonies of great and arctic skuas, and the eider duck also breeds there. Geologically, Noss exhibits striking erosion in sandstone and phyllites of the Old Red Sandstone age. The Royal Society for the Protection of Birds will continue to provide a warden, as before.

The Castor Hanglands nature reserve was declared by the Nature Conservancy in June last year, and the present declaration completes the reserve by bringing in an area of 113 acres, under a lease from the Forestry Commission—the western portion of Castor Hanglands Wood which adjoins Ailsworth Heath. The woodland fringe now added completes a series of habitat types characteristic of this part of the Midlands, few examples of which still remain. The grass heath, which is not represented on the other Nene reserves, merges into the fringing shrub margin of the oak–ash woodland. The whole area has long been known for its rich insect life and particularly for butterflies, such as the black hairstreak and the chequered skipper. There are two small pools which support a variety of aquatic vegetation. Access to this area and the Blacklands part of the reserve is by permit only, obtainable from the Conservancy's regional officer for East Anglia at 6 Upper King Street, Norwich.

The latest addition of a further 17¼ acres to Kingley Vale completes this reserve of approximately two hundred acres which was first declared in 1952. The reserve includes a famous natural yew wood, chalk grassland on the downland slopes, and an area of heath overgrown by scrub on the plateau of Bow Hill. The additional area is a well-developed heath on the clay soil of the plateau and provides a marked contrast to the grassland of the chalk slopes. The predominant plants are heather and other species typical of acid soils, but there are also some chalk grassland species which have deep roots penetrating to the underlying chalky soil. Thus the area is of particular value for studying the distribution of species which are restricted to either calcareous or to acid soils. As with the rest of the reserve, there are no restrictions of access, but permission is required to collect specimens, application for which should be made to the Conservancy's regional officer for the south at Furzebrook Research Station, Wareham, Dorset.

THE MEDICAL RESEARCH COUNCIL

REPORT FOR 1953–54

THE report for 1953–54 of the Medical Research Council (pp. v+274. Cmd. 9506. H.M.S.O. 7*s.* 6*d.* net) follows the plan used during recent years. The work of the Council's many establishments is given only in summary, together with a list of the scientific papers published by the Council's many workers, from which the reader may learn the extraordinarily wide range of the Council's activities; but the main part of the report discusses each year, from a broader point of view, some aspect of the general trends of medical research.

This year the report considers, in a fascinating article entitled "Modern Trends in Chemotherapy", the remarkable researches which are gradually transforming our methods of treatment of many serious diseases. Not the least interesting part of this article is its introductory account of the evolution of modern methods of research in this field and the development of the co-operation between biologists and biochemists which has enabled us either to attack directly biochemical processes upon which the lives and activities of pathogenic organisms depend or, in some instances, to reinforce the defensive mechanisms of the host, so that the host is enabled to deal more effectively with the pathogenic organism that invades its body. This phase of chemotherapeutic research began with the discovery by Dr. D. D. Woods that sulphanilamide derivatives exercise their antibacterial effects by interfering with a metabolite essential to the pathogenic organisms concerned, namely, *p*-aminobenzoic acid, the chemical constitution of which closely resembles that of sulphanilamide. Sir Paul Fildes then supplied the hypothesis that an effective chemotherapeutic agent will be a substance that interferes with some essential metabolic reaction of the pathogenic organism, and that such a substance should be sought among compounds biochemically similar to those normally utilized by the pathogen. This Woods–Fildes theory is a special application of the results of earlier work by Prof. J. H. Quastel and

Dr. Marjorie Stephenson, which showed that enzymic reactions are inhibited by compounds chemically similar to those in which the enzymes normally produce a change. This is a good example of the way in which academic research may lead to ideas of practical importance and of the valuable results that may result from the policy consistently followed by the Medical Research Council of fostering fundamental researches of a kind that may form the bases of advances in practical methods of actually treating disease.

For details of the remarkable biochemical work now being done by the Council's workers, the article just mentioned must be consulted. It deals with work on factors which influence radiosensitivity, the action of biologically active substances on tissue cultures, blindness in premature infants, pernicious anæmia, cortisone in the treatment of ulcerative colitis, trends in research in human malnutrition, the neurotic in industry, pneumoconiosis, analgesia in midwifery and research on the mechanism of virus infection. The reader in search of dramatic developments will certainly find them here. Dramatic undoubtedly are the results achieved by the staff of the Strangeways Laboratory at Cambridge. Directed by Dr. Honor B. Fell, this Laboratory has been quietly developing for many years the tissue-culture technique as a tool which has widespread applications. The brief account given in this report of some of the results achieved shows what can be accomplished by this technique. Work on the effects of vitamin A on chick ectoderm growing in tissue cultures has, for example, not only confirmed that absence or deficiency of vitamin A results in keratinization, but also it has produced the remarkable result that high concentrations of vitamin A can convert growing ectoderm into ciliated epithelium secreting mucus that is indistinguishable from the normal epithelium of the respiratory tract of the chick. It seems, therefore, that one of the functions of vitamin A is to control the structure and function of certain epithelial cells, and the intact animal seems able to pick out of the circulating fluids the level of vitamin A needed for its normal development. Not less interesting is the tissue-culture work done on the effects of substances produced by the thyroid gland and by insulin.

Dramatic also is the work outlined in this report on the cause of blindness that developed in the United States and in Britain in premature infants. This proved to be a result of the action of oxygen treatment normally given to these infants. A result of this treatment apparently may be that, when a premature infant is exposed to high concentrations of oxygen for the periods of time formerly considered to be necessary, the blood vessels supplying the retina of the eye become constricted and eventually the blood supply to the retina becomes obliterated. When the infant is afterwards returned to normal air with less oxygen in it, the retina demands, so to speak, more oxygen, and an overgrowth of blood vessels occurs which is so exuberant that it results in filling the back of the eye with fibrous tissue in which the retina is involved, so that all power of sight is irretrievably lost. The remedy that has now been successfully applied is a drastic reduction of the oxygen treatment.

These two examples of the work recorded in this report will suffice to indicate the quality of the beneficent work that is being done by the Council. As the report itself implies, the discoveries which attract public attention and bring great relief of suffering to mankind are inevitably based on long months of patient and unspectacular labour performed by many workers who each contribute something essential to the final triumphs. All these workers, whatever their status, deserve our gratitude, as do, indeed, all those others who work outside the Council's authority but contribute no less in their several ways to the general and continuous progress of medical research.

G. Lapage

UNIVERSITIES COUNCIL FOR ADULT EDUCATION

"Achievement under difficulty" is the dominant note in the report of the Universities Council for Adult Education for the year 1953–54 (Universities Council for Adult Education. Report on the year 1953–1954. Pp. 28. (Bristol: W. E. Salt, Hon. Secretary and Treasurer, 1955)). The timely financial assistance given by the Ministry of Education enabled extra-mural departments to carry on with their existing work and even to venture on a certain amount of exploratory work. While the total number of three-year tutorial classes fell, for the first time since the War, from the previous session's total of 1,001 to 974, the number of one-year sessional classes, which had fallen slightly in the previous session, rose by twenty-three to the record figure of 1,283. Six universities report increases in the number of three-year classes and no fewer than ten an increase in two types of longer courses. Moreover, London and Manchester achieved record numbers of three-year classes: the London total has been climbing steadily for some years and is now more than twice as large as before the War. The total number of students has increased with the number of classes.

A remarkable feature about the subjects of study is the rise of history to the leading place, with 684 classes out of the total of 3,994 as against 597 in the previous session and 584 in 1951–52. Most subjects show a substantial increase over the figures for the previous session, but only history, the sciences and the arts have yet recovered the ground lost since 1951–52. In the case of psychology, there has been a continued decline from 294 classes in 1950–51 to 184 in the present session. The number of courses in the physical and biological sciences increased by 56 during the year to a total of 434. Taken together, they stand fifth in the order of subjects, while the physical sciences alone stand higher than psychology, religion and government, and very little below philosophy.

A number of interesting courses and experiments was undertaken. Sheffield had large audiences for courses in "Twentieth Century Physics", "Electrons in Action", and various aspects of engineering; Bristol even larger audiences for "Seeing Atoms" and "The Living Brain"; while London was highest with the thousand who attended a course on "Atomic Energy". London held a rewarding residential course on "Embryology" for graduates in biology, and a similar 'refresher' course conducted by Birmingham, as one of an established series, had far-reaching results. The main problem in science was the provision of courses for non-scientists.

Interesting experiments have also been carried out in the supply of special courses for trade unionists.

AMINO-ACID SEQUENCE OF ALPHA-CORTICOTROPIN

By Prof. CHOH HAO LI and Drs. IRVING I. GESCHWIND, R. DAVID COLE, ILSE DOROTHEA RAACKE, J. IEUAN HARRIS and JONATHAN S. DIXON

Hormone Research Laboratory and Department of Biochemistry, University of California, Berkeley

THE isolation and partial structure of α-corticotropin, a polypeptide from sheep pituitary glands possessing adrenocorticotropic (ACTH) activity, have been reported from this laboratory[1-3]. In this preliminary communication, we wish to propose a complete amino-acid sequence, deduced from the structure of peptide fragments isolated from enzymatic and partial acid hydrolysates of the hormone.

Action of Pepsin

Earlier investigations demonstrated that limited digestion with crystalline pepsin effects the cleavage of peptides and amino-acids chiefly from the C-terminal portion of the molecule. The core material remaining after peptic digestion, which may be separated from smaller peptide fragments by precipitation in 25 per cent trichloroacetic acid solution, was shown to possess ACTH activity.

150 mgm. of α-corticotropin trichloroacetate[1,2] and 2·4 mgm. of crystalline pepsin were dissolved in 45 ml. of 0·01 *M* hydrochloric acid and kept at 37° C. for four hours. After the whole digest had been heated to 100° C. for two minutes, it was mixed with an equal volume of 50 per cent aqueous trichloroacetic acid. After the solution had stood for one hour at 0° C., the precipitate was removed by centrifugation. The supernatant fluid was freed of excess trichloroacetic acid by repeated extractions with peroxide-free ether, and was then taken to dryness by lyophilization. The dried residue, weighing 22·5 mgm., was dissolved in 0·1 ml. of water. A small aliquot containing about 0·2 mgm. of the residue was applied to paper as a spot, and the remaining solution was applied as a band (0·5 × 5 cm.) close to the spot. The chromatogram was developed by the descending procedure in the *n*-BuOH/HOAc/H_2O (4 : 1 : 5) system of Partridge[4]. After being dried, the 'spot' chromatogram, which was to serve as the guide strip, was cut out and sprayed with ninhydrin solution. The zones in the 'band' chromatogram corresponding to the spots on the guide strip (Fig. 1) were cut out and the material was eluted with 0·3 ml. of 5 per cent sodium bicarbonate. Each eluate was allowed to react with Sanger's reagent, fluorodinitrobenzene, in the manner described by Porter[5]; the reaction mixtures were acidified and fractionated by extraction first with ether and then with ethyl acetate. Both fractions were submitted to chromatography on paper with *tert*-AmOH/*iso*-AmOH/3 per cent NH_3 (2 : 1 : 3) as the developing solvent; each of the spots in these chromatograms was cut out and the material was eluted with 2 per cent ammonia. The hydrolysate of each eluate was analysed for N-terminal amino-acids by the chromatographic procedure of Levy[6], and for the remaining amino-acids by one-dimensional chromatography on paper in the solvent system *n*-BuOH/HOAc/H_2O (4 : 1 : 5). The C-terminal amino-acids in some of these peptide fractions were investigated by the carboxypeptidase procedure[1]. The following peptides[7] were identified: asp.glu; asp(glu,ala); asp(glu,ala)ser; glu(ala,ser); ser.glu; ser(glu,ala); ser(glu,ala,phe); glu.ala.phe; phe(pro, leu,glu), and pro(leu,glu,phe). Earlier investigations[1,3,10] showed that the single leucine residue is located in the C-terminal portion of the molecule, and that two of the three serine residues and one of the three phenylalanine residues occur in the sequence ser.tyr.ser.met.glu.his.phe . . . at the N-terminus. Thus, the following sequence can be deduced for the carboxyl end of α-corticotropin: . . . asp.glu.ala.ser. glu.ala.phe.pro.leu.glu.phe.

Action of Trypsin

50 mgm. of α-corticotropin trichloroacetate and 0·75 mgm. of crystalline trypsin were dissolved in 5 ml. of water and the *p*H of the solution was adjusted to 9·3–9·4 by the dropwise addition of 2 per cent ammonia. The whole solution was then diluted to 10 ml. with water and kept at 38° for 6 hr. After incubation, the digest was immediately lyophilized. The lyophilized product was submitted to chromatography on paper in the first dimension, in the solvent system *n*-BuOH/HOAc/H_2O/pyridine (30 : 6 : 24 : 20) of Waley and Watson[11], and then, in the second dimension, to zone electrophoresis on paper for 6 hr. at 11·5 volts per cm. in the buffer system γ-collidine/HOAc/H_2O at *p*H 7·0, described by Lockhart and Abraham[12]. When the paper was sprayed with ninhydrin, the typical pattern shown in Fig. 2 was revealed. The material corresponding to each spot in the pattern was accumulated by submitting the digest first to paper chromatography and then to paper electrophoresis with the aforementioned solvent systems. The eluate from each zone obtained in the

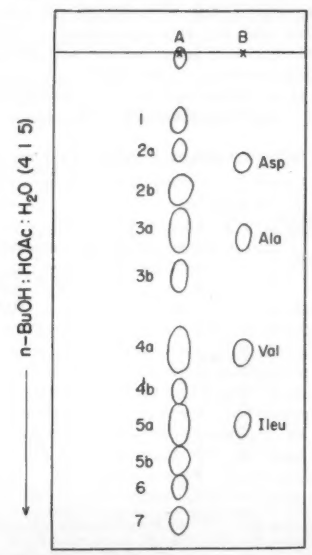

Fig. 1. Chromatogram of trichloroacetic acid-soluble peptides released by the action of pepsin on α-corticotropin

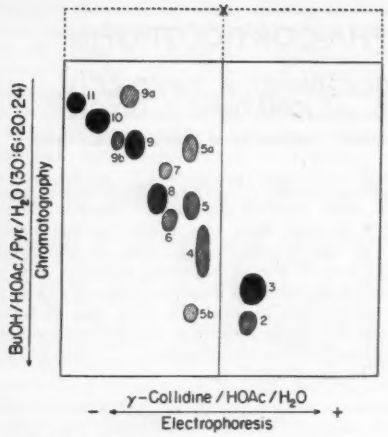

Fig. 2. Resolution of a tryptic digest of α-corticotropin by paper chromatography in the first dimension and by zone electrophoresis on paper in the second dimension

latter procedure was submitted to quantitative amino-acid analysis by the DNP-paper method[6], as well as to stepwise degradation, proceeding from the amino end of the peptide, by a modification[13] of the method of Edman[14]. Results disclose the occurrence of the following peptides in the tryptic digest of α-corticotropin: ser.tyr.ser(met,glu,his,phe)arg; try.gly.lys.pro.val.gly.lys; lys.arg; lys.arg.arg; arg.pro.val.lys; and val.tyr.pro.ala.gly.glu(asp$_2$,glu$_2$,ala$_2$,ser,phe$_2$,pro,leu).

Action of Chymotrypsin

50 mgm. of α-corticotropin trichloroacetate was dissolved in 2 ml. of water and mixed with 2 ml. of 0·2 *M* ammonium acetate buffer, at *p*H 8·2, containing 0·5 mgm. of crystalline chymotrypsin. After the mixture had been kept at 38° C. for 4·5 hr., it was placed in a boiling water-bath for two minutes to terminate the enzymatic activity. The slight coagulum formed was removed by centrifugation and the clear supernatant liquid was lyophilized. The digest was then submitted to zone electrophoresis on paper in a γ-collidine/HOAc/H$_2$O buffer of *p*H 6·7 [12] for 6 hr. at a potential gradient of 10·2 volts per cm. Fig. 3 presents a typical pattern after the paper strip had been sprayed with ninhydrin; the bands were further examined by means of stain reactions for tryptophan[15] and arginine[16]. It was found that band No. 7 gave the strongest colour reaction for these two amino-acids. The material in band No. 7 was then eluted with 3 per cent ammonia and submitted to chromatography on paper in the solvent system of Partridge[4]. The material from the main spot in the chromatogram was eluted and examined by a modification of the Edman procedure (Geschwind, I. I., unpublished work). The results gave evidence for the presence of the sequence . . . arg.try . . . in this peptide. (The sequence his.phe.arg.try . . . was found by applying the paper-strip modification[17] of the Edman procedure to a fraction obtained from countercurrent distribution of the core derived from extensive digestion of α-corticotropin with pepsin. This sequence confirms the arg.try linkage.)

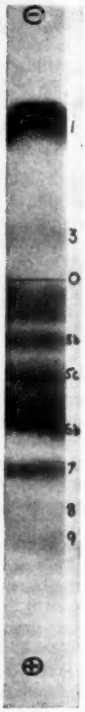

Fig. 3 Resolution of a chymotryptic digest of α-corticotropin by zone electrophoresis on paper

Partial Acid Hydrolysis of DNP-α-Corticotropin

The DNP-derivative of α-corticotropin was prepared according to the procedure previously described[18]. 50 mgm. of DNP-α-corticotropin was suspended in 1 ml. of 6 *M* hydrochloric acid; the suspension was sealed in a test-tube and kept at 110° C. for 5 hr. The separation and identification of DNP-peptide fragments in the partial acid hydrolysate were effected by paper chromatographic procedures similar to those employed for separating the products of peptic digestion (*vide supra*). This procedure disclosed, *inter alia*, the peptides pro(val$_2$,lys,tyr) and ala(gly,glu,asp); the quantitative estimations were

Table 1. Peptides obtained from Peptic, Tryptic, Chymotryptic, and partial Acid Digests of α-Corticotropin: Complete Amino-Acid Sequence of the Peptide Hormone

Hydrolytic agent	Peptide No.	Amino-acid sequence
Trypsin	5	ser.tyr.ser(met.glu.his.phe)arg
Chymotrypsin	7	arg.try( )
Trypsin	8	try.gly.lys.pro.val.gly.lys
Trypsin	10	lys.arg
Trypsin	11	lys.arg.arg
Trypsin	9	arg.pro.val.lys
Acid	B2–5	pro(val,lys,val,tyr)
Trypsin	2, 3	val.tyr.pro.ala.gly.glu(asp,asp,glu,ala,ser,glu,ala,phe,pro,leu.glu.phe)
Acid	WOE–4	ala(gly,glu,asp)
Pepsin	2b–1	asp.glu
Pepsin	2a–1	asp(glu,ala)
Pepsin	1–1	asp(glu,ala)ser
Pepsin	3b–1	glu(ala,ser)
Pepsin	4a–2	ser.glu
Pepsin	2b–2	ser(glu,ala)
Pepsin	4b–2	ser(glu,ala,phe)
Pepsin	4	glu.ala.phe
Pepsin	7–2	phe(pro,leu,glu)
Pepsin	7–3	pro(leu,glu,phe)
Complete sequence:		ser.tyr.ser.met.glu.his.phe.arg.try.gly.lys.pro.val.gly.lys.lys.arg.arg.pro.val.lys.val.tyr.pro.ala.gly.glu.asp.asp.glu.ala.ser.glu.ala.phe.pro.leu.glu.phe 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39

made visually on the basis of ninhydrin-sprayed chromatograms.

Table 1 summarizes the results obtained from peptic, tryptic, chymotryptic, and partial acid hydrolysates of α-corticotropin. From them, together with previously reported sequences for the N- and C-terminus[3], the complete amino-acid sequence of the hormone is established. Since no amino-acid sequence inconsistent with this formulation was encountered, it may be assumed that no appreciable transpeptidation has occurred during enzymatic digestion. Although no structure containing the sequence . . . lys.lys . . . has been found, there is evidence to suggest that the linkage postulated in positions 15–16 must exist. The specificity of trypsin would demand that the . . . gly.lys . . . bond (positions 14–15) not be split. Consequently, the N-terminal lysine of peptides 10 and 11, which together with peptide 8 are found in high yield, cannot represent position 14 and hence must occupy position 15. It should be noted that the location of the amide groups in the molecule has not been established. Previous studies[1,9] have shown that α-corticotropin contains two amide residues.

Recently, Bell and his co-workers[20] reported the purification and structure of β-corticotropin from hog pituitary glands. Both the ovine and the porcine hormones contain 39 amino-acids, the only difference being the occurrence of one less serine and one more leucine in β-corticotropin; this difference is accounted for by the . . . ala.ser . . . sequence (positions 31–32) in the sheep hormone in place of a . . . leu.ala . . . sequence in the porcine β-corticotropin. The only uncertainty reported in the structure of the latter[20] was in the sequence . . . ala(gl❓,glu,asp) . . . in positions 25–28. White and Landmann[21] reported the sequence . . . gly.ala.glu.asp . . . in these positions in corticotropin-*A*, which is also of porcine origin. In the ovine hormone, the sequence for these positions, as shown in Table 1, is: . . . ala.gly.glu.asp. Some uncertainty about the sequence of positions 25–28 was introduced when peptides 2 and 3 in the tryptic digest were re-investigated by the Edman procedure. However, a single experiment with acid hydrolysis (*WOE*-4) favoured the proposed sequence. Further investigation is being carried out.

Complete details will be published elsewhere.

We wish to acknowledge with thanks the generous support of the National Institutes of Health, the United States Public Health Service (Grant No. *G* 2907), the Albert and Mary Lasker Foundation, and Eli Lilly and Company, which have aided greatly in the present investigation.

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FORMATION OF TUBES BY A SIMPLE ROLLING ACTION: A NEW NORMAL-PRESSURE EFFECT

By M. J. EGAN and A. JOBLING
Ernest Oppenheimer Laboratory, Department of Colloid Science, University of Cambridge

IN the steel industry, it is known that, in the Mannesmann process[1], a red-hot rod of metal forms itself into a tube when rolled between rollers. Williamson[2] has recently described a similar phenomenon which he observed in the rolling of a certain natural Australian clay ('blue ball clay') and also with warm 'Plasticine'. He studied in great detail the microstructure of the clay with regard to its chemical constitution, water content, and particle size, shape and crystallographic orientation, and concluded that the phenomenon was specific to the microstructure and in particular to the difference in water content between the inner and outer regions of the specimen.

Weissenberg[3] has analysed the experimental observations and concludes from his theory of flow that the phenomenon should depend only on the macroscopic characteristics of the process and the material, and should be much more general than has hitherto been imagined. It should be observable as an effect of normal pressure in materials with the most varied types of microstructure and be particularly sensitive to the amount of elastic recovery present. When this amount approximates to zero, the plastic deformation caused by the rolling process should generate near the axis of the specimen a concentration of tensional normal pressures which suck in the end-planes of the specimen and open up radial cracks. This could continue under favourable conditions until a tube is formed. Tests with elastic recoveries progressively increasing from zero to large amounts should produce plastic and elastic deformations, and the latter should reduce the strength of the tensional pressures to zero and beyond this to compressions. Thus, in extreme cases, a reversion of the phenomenon of tube formation should be observed, as the compressions would tend to push out the end-planes of the specimen. The early stages of the sucking-in or pushing-out should be insensitive to changes in the initial shape of the specimen, but the completion of a tube by continued rolling should be facilitated by the choice of initial dimensions with a length to width ratio smaller than unity.

We were interested in testing Weissenberg's conclusions, particularly because it seemed unlikely that a merely macroscopic theory could predict qualitatively all the various widely differing normal pressure effects such as these and the better-known 'Weissenberg effects'[4,5] which occur under torsional shears and are almost diametrically opposed to those described here. Two series of tests were carried out.

We started the first series by reproducing and confirming Williamson's observations. We rolled tubes from warm 'Plasticine' and from an aqueous paste of a clay very similar in constitution to his 'blue ball clay'. Both materials had a macroscopic consistency which was putty-like and plastic, with no apparent elastic recovery. We then prepared a series of materials of similar macroscopic consistency but with widely differing microscopic structures by stirring liquids into aggregates of solid particles to a solid concentration of about 75 per cent (though this was not very critical). The rolling of flat-ended cylindrical specimens with a length to diameter ratio of about 0·5 produced tubes in every material of this series irrespective of the nature of the liquid phase (water, paraffin oil, or silicone oil) or whether the solid particles were coarse or fine, crystalline or amorphous, in the shape of plates (graphite), needles (asbestos), or spheres (starch). The effect of varying the dimensions of the specimen was most pronounced in cold 'Plasticine', from which Williamson failed to produce a tube. In this material we produced tubes by rolling cylindrical rods with initial length/diameter ratios equal to or smaller than 0·5, and found that the rolling of spheres and cylinders with a ratio equal to or larger than 1 (such as were used by Williamson) exhibited in the early stages a drawing-in of the ends; but the end cavities did not meet however long the rolling continued.

The appearance of cracks during rolling allowed a rough assessment of the pressure distribution to be made. An accumulation near the axis of tensional normal pressures was indicated by the opening-up of radial cracks originating near the axis and decreasing in width from the centre outwards (see Fig. 1). The effects of varying the chemical and physical properties of the components were difficult to assess; but, in a qualitative way, it was possible to distinguish two types. One type formed tubes by the sucking-in of the ends of the cylinder until the concavities met; for example, smooth pastes containing, in 'Nujol' (liquid paraffin): powders of aluminium, aluminium stearate, cement, clay, cornflour, graphite, icing sugar, iron, jeweller's rouge, lycopodium, polystyrene, 'Pyrex' glass, starch, and talc; in water: clay, icing sugar, lithopone; in silicone oil: graphite, icing sugar. The other type formed tubes by the opening-up of radial cracks with little or no drawing-in of the ends; for example, fibrous pastes of 'Nujol' and asbestos or of water and filter-paper pulp.

In a second series of tests, we investigated materials with a macroscopic consistency which was again putty-like but showed noticeable amounts of elastic recovery (as evidenced by bouncing or recovery from stretching) in contrast to the first group. Some extreme cases of such materials are a poly*iso*butylene with a molecular weight of about 20,000, silicone bouncing putty, and Reeves's 'putty' rubber, all of which on rolling produced elongated rods with convex ends and thus exhibited the opposite of the tube-forming phenomenon. Tests of the remaining materials in this series (Remington 'Everclean' rubber, and pastes of 'Plasticine'+rubber solution+talc, and vinyl chloride-acetate copolymer+dioctyl phthalate+china clay) showed poor reproducibility. The same material exhibited in successive experiments both drawing-in of the ends and the converse effect even with no deliberate variation of the experimental conditions. An assessment of these results has to be postponed until quantitative data are available under carefully controlled conditions of temperature, speed and pressure of rolling, etc.

Fig. 1. Tube formation and its opposite in different types of materials. The rolled specimens are viewed in elevation (top), plan (middle), and axial section (bottom). From left to right: cornflour in 'Nujol', asbestos in 'Nujol', poly*iso*butylene with a molecular weight of about 20,000

Fig. 1 illustrates the normal-pressure phenomena observed in rolling. Tube formation of the two types is shown in two materials of the first series of tests and the opposite phenomenon in an extreme material of the second series.

These two series of tests do not provide sufficient information to decide for or against Weissenberg's theory. However, such indications as have been obtained are consistent with his predictions of an accumulation of normal pressures near the axis of the specimen, and of a change of the pressures from tension to compression with an increase in the amount of elastic recovery. In any event, the application by Weissenberg of the macroscopic point of view has revealed the great generality of a new set of normal-pressure phenomena occurring in the shearing movement of the rolling process.

We thank Mr. A. J. Gaskin, of the Commonwealth Scientific and Industrial Research Organization, Melbourne, in whose department Williamson's experiments were performed, for bringing the phenomenon to our notice and for his continued interest and co-operation. We thank also Mr. J. E. Roberts and Mr. W. F. O. Pollett for help and advice in the experimental investigation, and Dr. J. H. Schulman for useful discussion about the materials under test. A number of firms and individuals have generously provided samples of powders of known size and shape.

[May 10

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LETTERS TO THE EDITORS

The Editors do not hold themselves responsible for opinions expressed by their correspondents. No notice is taken of anonymous communications.

A Measurement of the Earth's Magnetic Field by Nuclear Induction

EXPERIMENTS have been carried out recently to measure the total magnetic field in the vicinity of Christchurch, Hants, using the free precession technique briefly reported by Packard and Varian[1].

In these experiments, the protons in a sample of water are initially polarized magnetically at right angles to the earth's field, and then the polarizing field switched off non-adiabatically. The residual magnetic vector is free to precess about the earth's magnetic field F, and in so doing induces a signal voltage in a pick-up coil. The frequency f of the precession is simply related to the field by the equation

$$2\pi f = \gamma_p F,$$

where γ_p is the gyromagnetic ratio for the proton.

The frequency f at this particular site at Christchurch at 12.30 p.m. on June 30, 1955, was 1,997·22 c./s., which corresponds to a value for F of 0·46906 ± 0·00001 gauss.

The frequency was measured in a simple manner by beating the input signal with the second harmonic of a 1,000 c./s. valve-maintained tuning fork checked against Rugby and B.B.C. to about 1 part in 10^6. The beat pattern was photographed from the cathode-ray oscilloscope display and, by comparison with a crystal-derived 50-c./s. trace, estimated to 1 part in 600. The beat frequency was 2·784 ± 0·005 c./s., hence the error in precession frequency is only 1 part in 4×10^5. Since the latest available value[2] of γ_p is 26,753 ± 0·6 sec.$^{-1}$ gauss^{-1}, the computed value for the total magnetic field is therefore limited by this. The value of F obtained is the time average over the period of an observation, about 5 sec.

For relative measurements, where the value of γ_p is not required, differences of the order of 1 microgauss should be just detectable.

The experiment recommends itself for its extreme simplicity. The apparatus consists of a rugged and portable nuclear magnetometer head, requiring no careful orientation in setting up, and standard frequency-measuring equipment. Placing the head on a selected site and taking a reading requires only a few seconds.

The experiment does, incidentally, provide a striking means of demonstrating the nuclear relaxation times T_1 and T_2.

Full details of the method and results will be reported elsewhere.

G. S. WATERS

Signals Research and Development Establishment
(Ministry of Supply),
Christchurch, Hants.
Aug. 4.

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Colour of Tellurite Glasses

THE glass-forming properties of tellurium dioxide, and the interesting properties of some tellurite glasses have been described by Stanworth[1]. Certain of these glasses have possible applications as optical components owing to their high refractive indices. However, all the tellurite glasses were prepared using commercially available tellurium dioxide and were coloured, usually slightly, yellow-green. This is in contrast to the statement of Berzelius[2] that clear, colourless glasses could be made by fusing the tetratellurites of barium and the alkali metals.

It was considered probable that the colour of the glass originated from impurities present in the tellurium dioxide. Spectrographic examination showed that the amount of impurity in the glasses was very small, that calcium and strontium were the main impurities and that slight traces of aluminium, magnesium, sodium, iron and gold could be detected. Of these it was judged that iron was by far the most probable source of the coloration. Chemical analysis of some tellurite glasses for iron gave values between 0·004 and 0·007 per cent for the total iron expressed as Fe_2O_3, in the glasses exhibiting least colour.

A number of attempts were then made to prepare a sample of pure TeO_2, particular reference being paid to the iron content. According to Köthner[3], tellurium metal may be separated from all impurities, except antimony, by repeated distillation under reduced pressure. This method was applied by distilling tellurium (50 gm.) in a bent quartz tube connected to a water-jet pump. Half the tube was heated in a small electric furnace, and the middle fraction of the distillate was collected at about 650° under 20 mm. mercury pressure. This procedure was repeated four times. The product was converted to the oxide TeO_2, via the basic nitrate, by the method described by Marshall[4], thus effecting a further purification.

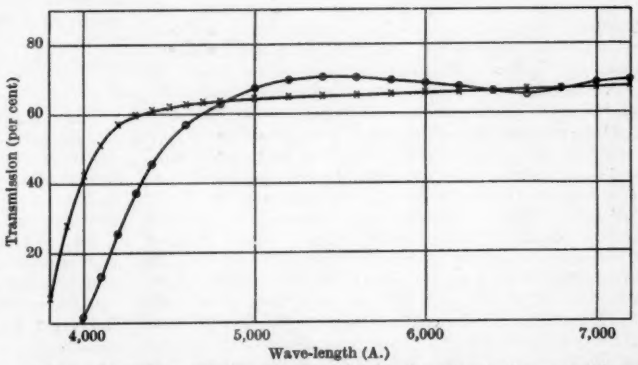

Fig. 1. Spectral transmission of barium tellurite glass of molecular composition $BaO.8TeO_2$. O, Melted in gold, using commercial tellurium oxide; ×, melted in gold, using purified tellurium oxide

Glasses of molecular composition $BaO.8TeO_2$ were melted from 'Analar' barium carbonate and various samples of TeO_2, and it was immediately evident that the TeO_2 purified as above gave glasses with much reduced colour. All the glasses were melted for 10 min., in a gold crucible at 900°, and were afterwards annealed from 310°. The glasses were ground and polished to a thickness of 3·5 mm. and the visual transmission curves obtained. The

curves relating to two glasses, one melted from commercial TeO_2 and the other melted from purified TeO_2, are shown in Fig. 1. Chemical analysis of these glasses showed that they contained respectively ~0·004 per cent and ~0·001 per cent iron, expressed as Fe_2O_3. Examination of the curves shows that with increasing purity of the glass, the ultraviolet absorption edge shifts towards shorter wavelengths. This is consistent with a decrease in proportion of ferric iron in the glass. Thus, it is concluded that the yellow-green colour of tellurite glasses melted from commercial materials is due to traces of iron impurities, and that the coloration may be greatly diminished by using a purer form of TeO_2.

It should be pointed out that the refractive index of the glass of composition $BeO.8TeO_2$ is approximately 2·1. Thus, there occurs during the transmission measurements a loss by reflexion at both surfaces amounting to about 24 per cent. This explains, in part, why the overall transmission of the glasses is low.

P. L. Baynton

Research Laboratory,
British Thomson-Houston Co., Ltd.,
Rugby.
May 11.

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A Method of determining Particle Size of Powders

Mills[1] recently described an apparatus for determining the mean diameter of the particles of a powder. This method, based on the measurement of the capillary pull of the interstitial pores, is not applicable in the case of very fine particles, since h, the capillary pull, cannot exceed the barometric height and l, the length of the column of the powder, must be kept as short as possible. The present communication describes in brief an alternative method (based on permeability principles) which is free from this limitation. The apparatus is illustrated in Fig. 1.

By opening the stopcock C, mercury from the reservoir R is introduced into the apparatus until the bulb E (about 25 c.c. capacity) is almost half full. The rest of the bulb E is filled with air-free water (or any other suitable wetting liquid). The powder under examination is closely packed over a plug of cotton or any other fibrous material of surface area much less than the powder at the constriction c, in the stem of the bulb F (25 c.c. capacity). The bulb F, detached from the main apparatus at the ground-glass joint, is then connected to a vacuum system at the lower end and water (or whatever wetting liquid is used) is poured in from above. The air contained in the pores of the powder is thereby replaced by the wetting liquid. The bulb is then mounted on the apparatus as shown in Fig 1. This ensures an air-free joint. Sometimes tiny bubbles of air may appear at the bottom of the cotton plug on the removal of the bulb F from the vacuum system. These can be removed by simple manipulation.

The stopcock D is then closed and the mercury reservoir R is lowered. When the difference in the mercury levels in the tubes A and B is about 50 cm. the stopcock C is closed and D is opened. Thus a

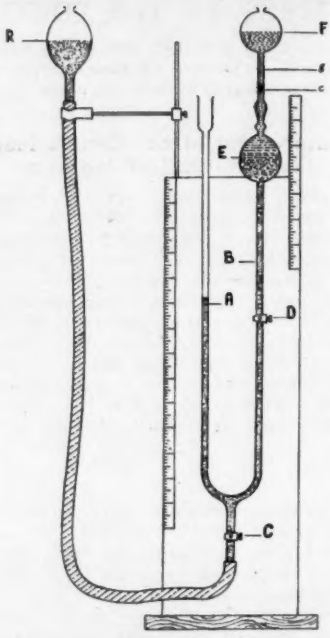

Fig. 1

certain amount of pressure deficiency is applied at the powder end and the liquid begins to flow through it. The level of mercury in the tube A begins to rise. The time (t) taken by the mercury level to rise through a given length, say, 5 cm., is noted. Applying Poiseuille's equation with suitable modifications for flow of liquids through porous media[2], and taking into account the flow under gradually decreasing pressure head, as in the present case, the following expression can be deduced:

$$r = \frac{1-\varepsilon}{\varepsilon}\sqrt{\frac{0{\cdot}006905\, L\eta R_1^{\,3}}{\varepsilon R^2 t}\log\frac{l_0}{l}}$$

where r is the mean particle radius, η is the coefficient of viscosity of the wetting liquid, R_1 is the radius of the tube A, R is the radius of the tube g, l_0 is the initial and l the final difference in the mercury levels in the two limbs, and ε is the pore space per c.c. of the powder.

The method was tested on several powders, varying in mean diameters from 0·015 to 0·0005 mm. Water and benzene were used as experimental liquids. The results obtained with both these liquids were in fairly good agreement with one another. The mean diameters were also calculated by microscopic counts and by Mills's method wherever it was applicable. The values obtained by the various methods were found to be of the same order.

M. L. Lakhanpal
V. D. Anand
B. R. Puri

Chemistry Department,
Panjab University,
Hoshiarpur, India.
April 2.

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Growth Spirals in Electrodeposited Copper

It was first pointed out by Frank[1] that the termination of screw dislocations in a crystal face would produce steps, by the propagation of which crystal growth could take place. Such steps would obviate the need for two-dimensional nucleation and thus allow crystal growth to proceed at considerably lower supersaturations than those required to form two-dimensional nuclei. Frank predicted that the presence of an isolated dislocation on a close-packed crystal face would allow this to grow *ad infinitum* in the form of an ascending spiral. This prediction was afterwards substantiated experimentally by observations of crystals grown both from the vapour and from solution. The spirals of silicon carbide grown from the vapour by Verma[2], and those of cadmium iodide grown from solution by Forty[3] may be quoted as examples.

No observations of spirals grown by electrodeposition seem, however, to have been reported. A recent examination of the surface of electrodeposited copper has led to the identification of spirals, and these must be assumed to have originated in a manner similar to that discussed in the previous paragraph. The copper was deposited at an average current density of 10 m.amp./cm.^{2} on a polycrystalline sheet of copper which had been cold-rolled and annealed so that a high proportion of the grains were oriented with their (100) planes parallel to the surface of the sheet and their [001] directions parallel to the rolling direction. The cathodes were electropolished prior to plating.

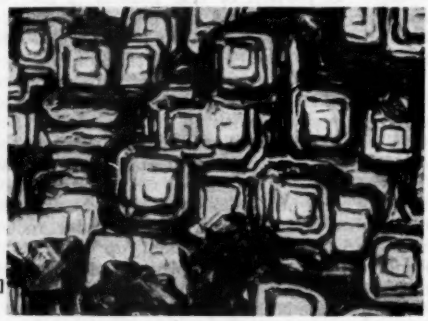

Fig. 1. Growth spirals in copper electrodeposited from an acid copper sulphate bath. (× 570)

Fig. 2. A growth spiral in copper electrodeposited from a neutral copper sulphate bath. (× 940)

Two types of spiral have been observed: (*a*) those deposited from aqueous $N/2$ copper sulphate + $N/2$ sulphuric acid solution, in which the rate of growth appears to have varied with crystallographic direction (see Fig. 1); (*b*) those deposited from neutral aqueous $N/2$ copper sulphate, in which growth was insensitive to crystallographic direction (see Fig. 2).

The conditions under which these spirals grow are now the subject of investigation. Plans are in hand to produce a continuous photographic record of the development of these spirals and of other features of crystal growth encountered in electrodeposition. This will be done by placing a suitably designed electrolytic cell on the stage of a microscope fitted with a reflecting objective. Such an objective may easily be corrected for the refractive index of the plating solution.

Since writing this communication, my attention has been directed to a photograph of a spiral on the surface of electrodeposited silver–indium alloy, reproduced in a paper by Raub[4]. This spiral is visible to the naked eye, but no details are given of the way in which it has been produced.

H. J. Pick

Department of Industrial Metallurgy,
University of Birmingham.
May 16.

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Partition Chromatography of Synthetic Detergents

In the course of a study on the adsorption at liquid/solid and liquid/air interfaces, difficulties were encountered in identifying small quantities of adsorbed detergents and in separating mixtures of such substances containing alkyl groups differing in length.

A convenient method of separation has now been developed by means of paper partition chromatography. The compounds mainly dealt with were the normal sodium alkyl sulphates, the number of carbon atoms in the hydrocarbon chain ranging from twelve to eighteen. However, with minor modifications the method was successfully applied to alkyl aryl sulphonates, secondary alkyl sulphates, quaternary ammonium and pyridinium salts.

The methods of ascending and circular[1] chromatography were employed. Whatman No. 1 filter paper was impregnated with a long-chain fatty alcohol, usually cetyl alcohol, which acted as stationary phase; this was applied from a 1 per cent ethanolic solution. The mobile phase consisted of an aqueous ethyl alcohol solution saturated with cetyl alcohol. The concentration of this solution varied according to the alkyl sulphates to be separated. The chromatogram of the detergent mixture was developed for 10–24 hr., and the paper dried. It was then immersed in 0·5 per cent cupric acetate and sprayed with a 0·05 per cent solution of rhodamine 6*GB*. After drying, the detergent spots appeared crimson on a pink background in daylight, and dark purple on a yellow background under ultra-violet light. R_F values were determined for various concentrations of ethyl alcohol and are shown in Table 1.

Table 1

Concentration of ethanol	No. of carbon atoms in *n*-alkyl group			
	12	14	16	18
50	0·88	0·50	0·11	0
62	1·0	0·70	0·39	0·07
75	1·0	0·90	0·50	0·15

By a similar procedure applied to 'Teepol', it was possible to obtain resolution into six well-defined components. It was, however, necessary to reduce the concentration of the mobile phase owing to the high solubility of secondary alkyl sulphates in ethyl alcohol. Resolution of commercial cetyl pyridinium chloride was also achieved by the above method, when four distinct compounds were obtained; the indicator used for cationic compounds was bromocresol green.

Other solvent systems are now being investigated, as well as a method for continuously changing the composition of the mobile phase, to achieve yet better separation and to enable quantitative determinations to be made.

A full account of this work will be published elsewhere. I wish to thank Mr. R. E. Wagg for helpful discussion and the Director of the British Launderers' Research Association for permission to publish this communication.

F. Franks

British Launderers' Research Association,
The Laboratories,
Hill View Gardens,
Hendon, N.W.4.

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Probable Nature of an Artefact in the Paper Chromatography of Thyroxine caused by Trichloracetic Acid

Interference of trichloracetic acid with the paper chromatography of adrenaline analogues and of histamine, using *n*-butanol/acetic acid/water (4 : 1 : 5), has already been reported[1,2]. A similar artefact is described below, affecting another compound, thyroxine, run in a different solvent system, *n*-butanol/dioxane/2 *N* ammonia (4 : 1 : 5). No effect of this nature is mentioned by Gross[3] in his review on the chromatography of thyroid hormones.

Shepherd and West[1] have been successful in removing trichloracetic acid from aqueous solutions before chromatography by treatment with the anion exchange resin 'Amberlite *IRA*-400'. Nevertheless, it was felt that an alternative method might prove useful in certain cases. Since trichloracetic acid is a strong acid, having a *pK* of 0·7 (Bell[4]), it seemed likely that electrolytic desalting would extract trichloracetate from aqueous solution, although neither Consden, Gordon and Martin[5] nor Dent[6] indicate whether the procedure is applicable to this ion. Consequently, an examination of this question was undertaken.

The thyroxine artefact was first encountered in experiments intended to discover whether the precipitation of plasma proteins by trichloracetic acid could cause the iodination of unsaturated plasma lipids by radioactive inorganic iodide; the possibility of this process occurring had been suggested by some observations on the behaviour of pure substances[7]. A plasma sample, which contained 0·1 mgm. heparin/ml., was obtained from a thyrotoxic patient who had received 10 mc. of radioiodine 48 hr. previously. A portion of this plasma (2 ml.) was treated with 20 ml. of 10 per cent (w/v) trichloracetic acid and the precipitated proteins washed three times with 10 per cent (w/v) trichloracetic acid. The precipitate was suspended in 5 ml. of water, brought to *p*H 4 with 1 *N* sodium hydroxide and extracted successively with 15 ml., 10 ml. and 5 ml. of water-saturated *n*-butanol and the extracts combined. Another 2-ml. portion of plasma was brought to *p*H 4 with 2 *N* hydrochloric acid and extracted directly. The *n*-butanol extracts were evaporated to dryness on a water-bath at 80° under reduced pressure and each residue taken up in 1 ml. of *n*-butanol. For chromatography, 50-μl. samples of these extracts were dried, 10 μl. at a time, on to a sheet of Whatman No. 1 paper, 100 μgm. of thyroxine being added as carrier to certain of the spots. The chromatogram was developed for 18 hr. in *n*-butanol/dioxane/ammonia using the descending method. The radioautograph of Fig. 1 was then prepared by placing the chromatogram in contact with 'Ilfex' double-coated X-ray film for 48 hr. Distortion of the thyroxine spot is seen to originate from those extracts which contain trichloracetic acid and spreads to adjacent runs which contain no trichloracetic acid.

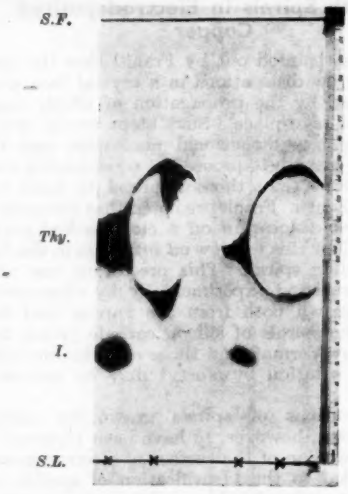

Fig. 1. Radioautograph showing trichloracetic acid interfering with the chromatography of endogenous radioactive thyroxine in extracts of plasma and plasma proteins. Scale in cm.; *S.F.*, solvent front; *S.L.*, starting line; *Thy.*, thyroxine; *I.*, iodide. (*A*) Original plasma; no trichloracetic acid; thyroxine carrier (100 μgm.). (*B*) Protein precipitate containing trichloracetic acid; thyroxine carrier (100 μgm.). (*C*) As (*A*) without carrier. (*D*) as (*B*) without carrier

The efficiency of the electrolytic desalting process was tested by noting how the chromatography of 50 μgm. thyroxine was affected by 50 μl. of a 2·5 per cent (w/v) trichloracetic acid solution before and after electrolysis of the latter for 1 hr. in a commercial model (supplied by the Shandon Scientific Co., London) of Dent's[6] desalter (initial current 0·9 amp.). The trichloracetic acid (in five portions) and thyroxine solutions were dried separately on to each spot and the chromatograms were developed for 21 hr. in *n*-butanol/dioxane/ammonia using the ascending method. Thyroxine was detected by spraying the paper with 0·2 per cent (w/v) ninhydrin in water-saturated *n*-butanol and heating it at 90° for 5 min.

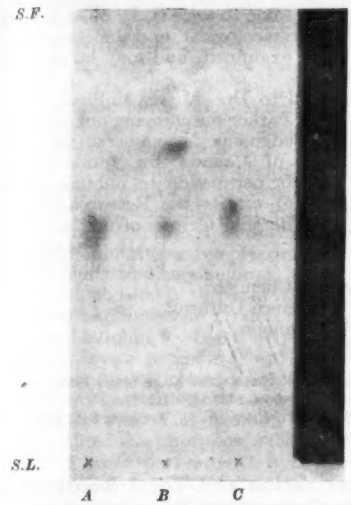

Fig. 2. Chromatogram showing the effect of trichloracetic acid on thyroxine chromatograms before and after electrolytic desalting. Scale in cm.; *S.F.*, solvent front; *S.L.*, starting line. (*A*) Thyroxine (50 μgm.) alone. (*B*) Thyroxine (50 μgm.) and 50 μl. of 2·5 per cent trichloracetic acid before electrolysis. (*C*) Thyroxine (50 μgm.) and 50 μl. of 2·5 per cent trichloracetic acid after electrolysis

Fig. 2 shows that electrolytic desalting causes the 'double spot' artefact to disappear. However, trichloracetic acid is probably not completely removed, since spot (*C*) shows an increase in the R_F of thyroxine relative to spot (*A*). Incomplete desalting has been observed in the case of other ions and is treated theoretically by Consden, Gordon and Martin[5].

There are two possible reasons why trichloracetic acid might cause chromatographic artefacts. Either loose chemical combination might take place between it and one or more of the substances being chromatographed[1,3], or the acid could interfere with the chromatographic solvent system. The form and spread of the artefacts shown in Fig. 1 favour the latter explanation. In this connexion it should be noted that solvent systems containing *n*-butanol are highly sensitive to changes in the degree of saturation of the non-aqueous with the aqueous phase[6], and it seems likely that trichloracetic acid, which is strongly hygroscopic, could cause such changes to occur.

I wish to thank Dr. H. Miller for preparing the radioautograph, Prof. G. M. Wilson and Dr. D. R. Wood for their interest in this work, and the Board of Governors of the United Sheffield Hospitals for financial assistance.

J. D. Acland
Department of Pharmacology and Therapeutics,
University of Sheffield,
and
Sheffield Royal Infirmary.
May 26.

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Decomposition Flame of Methyl Nitrite

When a stream of methyl nitrite vapour issuing from the mouth of an upright cylindrical glass tube about 5 cm. in diameter is ignited it burns in the air as a lambent diffusion flame, greyish-yellow in hue. At the inner surface of the diffusion flame an orange-red zone forms as a cone at the mouth of the tube. If the rate of flow is reduced, this orange-red inner flame peels away from the diffusion flame and slowly descends the tube as a flat disk surmounted by a fainter, conical afterglow of the same colour, easily visible in a darkened room. No oxygen is necessary for its propagation. After it has entered the tube it is not affected if the diffusion flame at the mouth is extinguished. It is the decomposition flame of pure methyl nitrite.

The decomposition flame is not propagated downwards in tubes with diameters much less than 2 cm. In wider tubes it may be stabilized at any point by adjusting the rate of flow. Its speed, measured in tubes of 3·9 and 6·2 cm. diameter, is about 3·0 and 2·5 cm. sec.$^{-1}$ respectively. In the presence of small amounts of oxygen or of ammonia, the flame burns more readily without any obvious alteration in its nature.

From the decomposition flame formaldehyde is liberated and condenses (as paraformaldehyde) on the walls of the tube downstream of the flame. Farther from the flame a brown, resinous tar is deposited. Nitric oxide is also present and forms, in the air above the flame, the familiar brown fumes of nitrogen dioxide. In a cylindrical tube of this type, the decomposition flame is too faint for convenient emission spectroscopy. An attempt was made to maintain the same flame under conditions in which the flame would be brighter and thus more suitable for spectroscopy by establishing the premixed oxygen – methyl nitrite flame on a sintered-disk burner and then cutting off the oxygen supply. On a 2·8-cm. diameter burner it was possible to reduce the oxygen/nitrite ratio to only 0·1 mole per mole and to maintain a flame very closely resembling the decomposition flame in a tubular burner. The odour of formaldehyde was again marked and a white smoke of paraformaldehyde visible. Absorption spectroscopy showed that nitric oxide passed through the flame without undergoing complete reduction. Relatively little oxidation occurred, and this flame, although maintained in part by oxygen, was primarily the decomposition flame of methyl nitrite.

A related phenomenon may be recognized on the nitrite side of the oxygen – methyl nitrite diffusion flame[1]. Far from the oxygen supply an orange-red zone of flame is formed. Absorption spectroscopy shows that nitric oxide is formed on the nitrite side of this zone, where the absorption by the nitrite begins to fade away, and that it is consumed in the zone itself, obviously by reaction with organic breakdown products of the nitrite, because CN and NH bands are observed in emission.

Although the thermal decomposition of the simple alkyl nitrites has recently been shown to be accompanied by chemiluminescence[2], this is a remarkable and unexpected flame. Its precarious existence is emphasized by the large quenching diameter; its burning velocity—about 3 cm. sec.$^{-1}$ at atmospheric pressure—makes it perhaps the slowest flame known. According to Steacie[3] and to Rice and Rodowskas[4], the normal thermal decomposition of the alkyl nitrites begins by O—N bond fission :

$$R\text{CH}_2\text{ONO} \rightarrow R\text{CH}_2\text{O} + \text{NO} \quad E_{act} \sim 37 \text{ k.cal.} \quad (1)$$

and ends with the formation of aldehyde, alcohol and nitric oxide:

$$R\text{CH}_2\text{ONO} \rightarrow 0{\cdot}5\ R\text{CH}_2\text{OH} + 0{\cdot}5\ R\text{CHO} + \text{NO} \quad \Delta H \sim 0 \text{ k.cal.} \quad (2)$$

Neither this reaction (2), which is almost thermoneutral, nor any in which there is complete conversion to nitric oxide, can account for a decomposition flame. For the release of the necessary heat some of the nitric oxide must be reduced and nitrous oxide or nitrogen formed:

$$\text{CH}_2\text{ONO} \rightarrow 0{\cdot}5\ \text{N}_2\text{O} + 0{\cdot}5\ \text{H}_2\text{O} + \text{CH}_2\text{O} \quad (\text{or CO} + \text{H}_2) \quad \Delta H = -30 \text{ k.cal.} \quad (3)$$

$$\text{CH}_2\text{ONO} \rightarrow 0{\cdot}25\ \text{N}_2 + 0{\cdot}5\ \text{H}_2\text{O} + \text{CH}_2\text{O} \quad (\text{or CO} + \text{H}_2) + 0{\cdot}5\ \text{NO} \quad \Delta H = -29 \text{ k.cal.} \quad (4)$$

In practice, decomposition may be expected to lie between the last three extremes.

Peter Gray
Department of Chemical Engineering,
University of Cambridge.

A. R. Hall
H. G. Wolfhard
Royal Aircraft Establishment,
Rocket Propulsion Department,
Westcott, Bucks.
May 17.

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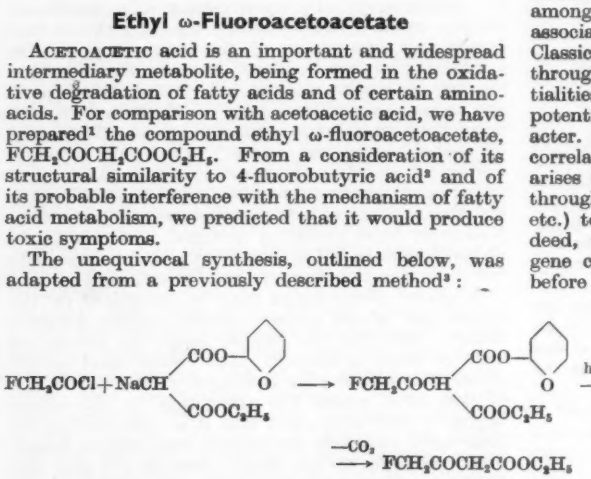
Ethyl ω-Fluoroacetoacetate

Acetoacetic acid is an important and widespread intermediary metabolite, being formed in the oxidative degradation of fatty acids and of certain amino-acids. For comparison with acetoacetic acid, we have prepared[1] the compound ethyl ω-fluoroacetoacetate, $\text{FCH}_2\text{COCH}_2\text{COOC}_2\text{H}_5$. From a consideration of its structural similarity to 4-fluorobutyric acid[2] and of its probable interference with the mechanism of fatty acid metabolism, we predicted that it would produce toxic symptoms.

The unequivocal synthesis, outlined below, was adapted from a previously described method[3]:



Ethyl ω-fluoroacetoacetate was obtained in 35 per cent overall yield as a colourless liquid with an odour almost indistinguishable from that of ethyl acetoacetate (b.p. 78–80° C./12 mm., and n_D^{25} 1·4180; found: C, 48·64; H, 6·26; $\text{C}_6\text{H}_9\text{O}_3\text{F}$ requires C, 48·64; H, 6·08 per cent). It readily formed a 2,4-dinitrophenylhydrazone derivative (m.p. 91–91·5°; found: C, 43·71; H, 4·16; N, 17·19. $\text{C}_{12}\text{H}_{13}\text{O}_6\text{N}_4\text{F}$ requires: C, 43·90; H, 3·99; N, 17·07 per cent).

It proved to be toxic to mice (L.D. 50, *c.* 2·5 mgm./kgm.). Its pharmacological and biochemical properties are being examined, and may be reported at a later date.

We are grateful to Drs. M. K. McPhail, F. C. G. Hoskin and J. M. Parker for carrying out the toxicity assays. Acknowledgment is made to the Defence Research Board of Canada for funds (Contract *DRB X*-24) and for permission to publish this work (Report No. *SW*-5), and to the Research Council of Ontario for a scholarship for one of us (R. R. F.).

R. R. Fraser
F. L. M. Pattison
Department of Chemistry,
University of Western Ontario,
London, Canada.
March 8.

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Characterization and Total Recovery of the Component Proteins of a Deoxyribonucleoprotein

Recent developments suggest that the normal nuclei of all somatic cells of an organism contain the same quantity[1] and kind[2] of deoxyribonucleic acid, but that the different cell types within the organism may differ[3] in regard to the proteins associated with deoxyribonucleic acid: deoxyribonucleic acid appears to be specific for species and the associated proteins specific for cell type. The deoxyribonucleic acid of a species has been shown[4] to be multiple with regard to nucleobase ratios and may consist of as many chemical individuals as there are genes, while at the same time among different species the deoxyribonucleic acid-associated proteins of similar organs may be similar. Classical genetics postulates that each cell type is, through its chromosomes, *endowed* with all the potentialities of the species, but *expresses* only those potentialities which make up its own specific character. If the deoxyribonucleic acids are the physical correlate of the genetic potentialities, the implication arises that cellular differentiation may be mediated through attachment of cell-specific proteins (histones, etc.) to species-specific deoxyribonucleic acids. Indeed, the hypothesis that the former function as gene conditioners was advanced by Stedman[5] long before the emergence of chemical proof for the multiplicity of deoxyribonucleic acid, and has recently been reasserted[6] on the basis of experimental evidence for the cell-type specificity of certain preparations of deoxyribonucleic acid-associated proteins.

In view of these developments, the comprehensive chemical characterization of the proteins associated with deoxyribonucleic acid of different tissues (which began eighty years ago with the work of Miescher) has attained new importance. Along with others, we have in recent years been studying the protein moiety of calf thymus nucleoprotein. We have developed a working procedure which yields essentially

all of the protein associated with the deoxyribonucleic acid of calf thymus nucleoprotein, in the form of three major fractions. Quantitative recovery is shown by the fact that the products contain all the sulphur and none of the phosphorus of the thymus nucleoprotein and account for its weight after subtraction of deoxyribonucleic acid corresponding to its phosphorus content.

Thymus nucleoprotein is obtained by extraction of homogenized fresh calf thymus tissue with water at 2° for 24 hr., centrifugation and precipitation in 0·14 *M* sodium chloride, followed by several re-precipitations. Four successive preparations, made from glands obtained at the slaughter house over a one-year interval, showed in terms of dry, salt- and lipid-free thymus nucleoprotein: phosphorus 4·20 ± 0·03 per cent and sulphur 0·31 ± 0·01 per cent (av. dev.). A modified Sevag procedure, applied to the fresh, moist thymus nucleoprotein precipitate, and consisting of a series of careful extractions and re-extractions at *p*H 11·0 with 1 *M* sodium chloride[7], yields essentially all of the phosphorus-free protein. Treatment of this latter protein with hydrochloric acid of *p*H 2·5, combined with high-speed centrifugation, separates it into soluble histone and residual protein. These products, properly washed and clarified, are neutralized and lyophilized. So far, no means have been found for re-dissolving the residual protein and examining its purity.

The histone fraction has been examined by fractional precipitation and by ultracentrifugal analysis. Successive adjustment of a histone solution to *p*H 10·3, 10·5 and 11·1 yielded three fractions of similar size which did not differ significantly from the whole histone in their nitrogen/sulphur and nitrogen/tryptophan ratios. Nevertheless, ultracentrifugal analysis of the whole histone revealed two major components. The faster of the two represents 63 per cent of the histone, yields a molecular weight estimate of 140,000 and contains methionine and cystine, as well as tryptophan. The slower component corresponds to 37 per cent of the histone, has a molecular weight of 11,000–16,000 and appears to contain one molecule of methionine, but no cystine or tryptophan. Table 1 gives a condensed summary of the preparative and analytical results.

Table 1

Fraction	Weight (per cent)	N (per cent)	S (per cent)	Methionine (per cent)	Cystine (per cent)	Tryptophan (per cent)
Nucleoprotein	100	18·5	0·31			
Whole protein	58	18·4	0·55	1·70	0·65	0·32
Residual protein	9	18·5	0·70	1·57	1·34	0·99
Whole histone	49	19·6	0·51	1·69	0·56	0·19
'Fast' histone	31	19·4	0·70	2·41	0·67	0·23
'Slow' histone	18	18·6	0·20	0·82	0·09	0·05

The use of dialysis as a means of separating the 'fast' from the 'slow' histone appears attractive, but is beset with difficulties and problems. Upon continuous dialysis of whole protein or whole histone, considerably more nitrogen than that corresponding to the 'slow' histone appears permeable. Because of these observations, which await explanation and resemble those of others[8], dialysis has not been employed in our fractionation. Several other authors[8,9] have recently reported a pair of histone fractions of low and high molecular weight, and it is noteworthy and puzzling that two of the procedures (Ahlström, Hamer) included extensive dialysis.

Our 'fast' and 'slow' histones showed sedimentation constants of $s^0_{20} = 8{\cdot}40\ S$ and $1{\cdot}59\ S$, respectively (2·1 per cent in 0·18 *M* sodium chloride at *p*H 8·1). The constants reported by others for the slower fraction range from 0·9 to 2·0, and for the faster one from 8·7 to 30. Because of different experimental conditions the significance of the discrepancies is uncertain. In view of the aggregative tendencies of histones[6], the wide range of values reported for the 'fast' fraction, from 8·4 for our preparation to a maximum of 30, may reflect increasing degrees of aggregation.

We wish to thank Dr. Sam Sorof, who has provided the ultracentrifugal results, and Mr. Joseph J. Kolb, who has aided in the analytical work. A detailed account will appear elsewhere[10].

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G. Toennies
B. Bakay

Lankenau Hospital Research Institute,
and
Institute for Cancer Research,
Philadelphia 11, Pa. March 17.

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Is Fusaric Acid a Vivotoxin?

While fusaric acid has been isolated and identified from culture filtrates of a number of *Fusaria*, its detection *in vivo* in diseased host plants has not yet been achieved in order to establish its vivotoxic complicity in wilt diseases[1]. Recent work of Zähner[2] on the detection and estimation of fusaric acid by chromatographic and bioassay techniques suggests the possibility of detection of fusaric acid *in vivo* in wilting host plants. We have been employing various chromatographic techniques, particularly the circular macro-[3] and micro-[4] techniques developed by one of us, for the detection and quantitative estimation of fusaric acid, and experienced considerable difficulty in obtaining sharp demarcation of the bands and reproducible R_F values to facilitate quantitative estimation. Fusaric acid detected with brom cresol green indicator gives a diffused and ill-defined yellow band in a blue background, possibly due to the poor ionization of the acid. The difficulty was overcome by preliminary conversion of fusaric acid into its copper complex on the filter paper with copper sulphate and irrigating the complex with excess copper with *n*-butanol/acetic acid/water (4 : 1 : 5). The quantitative estimation of fusaric acid has been carried out with this technique based on the area method and will be published shortly; we have used the technique for the detection of fusaric acid *in vivo* in wilted cotton plants.

Cotton plants (Karunganni 2, *Gossypium arboreum*) susceptible to *Fusarium* wilt were grown in pots containing 500 gm. of sterilized garden soil mixed with 10 per cent soil–oat inoculum of *Fusarium vasinfectum* Atk. Visible symptoms of wilt were noted after ten days. The roots, shoots and leaves from wilted plants were collected, washed thoroughly with sterile distilled water and the sap squeezed out by maceration, and about 0·75 μl. of the clear sap spotted on circular filter paper (Whatman No. 1, 7·4 cm.) followed by copper sulphate (4 μgm./0·75 μl.). The paper was dried and irrigated with the solvent according to the technique reported earlier[2]. At the end of the period of irrigation the papers were dried and sprayed with 0·05 per cent rubeanic acid in acetone. The fusaric acid – copper complex and excess copper appeared as sharp green bands and were intensified by exposure to ammonia vapour as described elsewhere[2]. R_F values were computed on the microscope. Table 1 gives the R_F values of copper and the copper – fusaric acid complex in controls and in saps of roots, shoots and leaves of wilting cotton plants in the three typical solvent mixtures *n*-butanol/formic acid/water (5 : 3·5 : 5), *n*-butanol/acetic acid/water (4 : 1 : 5) and *n*-butanol/acetic acid/water (3·5 : 1·5 : 5), indicating the presence of fusaric acid *in vivo*. Chromatograms of saps of healthy cotton plants under similar conditions did not show the copper – fusaric acid complex bands. The results were confirmed with six more solvent mixtures to establish conclusively the presence of the toxin *in vivo*. The consistent presence of the complex bands in chromatograms of diseased sap in the positions corresponding to those of the copper – fusaric acid controls in every case would eliminate the possibility of interference by other metabolites which might also form complexes with copper.

Work on the quantitative aspects with resistant and susceptible varieties of cotton is under way and will be reported elsewhere.

Table 1

Material spotted	R_F-values *n*-Butanol/formic acid/water (5 : 3·5 : 5)	*n*-Butanol/acetic acid/water (4 : 1 : 5)	*n*-Butanol/acetic acid/water (3·5 : 1·5 : 5)
1 Copper	0·157	0·494	0·666
2 Copper–fusaric acid complex	0·088	0·273	0·617
3 Diseased root sap	0·086	0·266	0·610
4 Diseased shoot sap	0·088	0·265	0·602
5 Diseased leaf sap	0·083	0·269	0·617
6 Saps of healthy plants (root, shoot or leaf)	No bands in the positions of the copper complex		

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K. Lakshminarayanan
D. Subramanian

University Botany Laboratory,
Madras 5. July 6.

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Nerve Endings as Transducers of Thermal Stimuli in Lower Vertebrates

It is now generally accepted[1] that the changes in impulse frequency in a sensory nerve are the result of processes which alter the state of polarization of the nerve membrane in the sense organ. In thermoreceptors, and especially in those[2] in which the response to cooling is an increase in the frequency of discharge, the mechanism whereby the change of temperature can cause a change in membrane polarization remains unknown.

The existence of this change of polarization is suggested by the following experiment on the ampullæ of Lorenzini of *Raja*. By passing a weak direct current between the sensory nerve and the outside of the capsule surrounding the sense organs, it is possible to alter the membrane polarization of the nerve endings and thereby the frequency of the spontaneous discharge (cf. ref. 3); the relationship between the strength of the applied current and the change in the spontaneous frequency is linear. If a standardized sequence of temperature changes is applied while a constant current is passing (Fig. 1), the responses to the thermal stimuli are added quantitatively to the responses to the electrical stimuli. The thermal response (in terms of the change in the number of impulses per second) remains the same whatever the level of the spontaneous frequency at the start of the sequence. This suggests that the temperature change is acting on the mechanism of the repetitive discharge at the same point as the electrical polarization. A similar experiment on the lateralis organs of *Xenopus laevis* is shown in Fig. 2 (the response of the lateralis organs of *Xenopus* to temperature change is similar to that of the ampullæ of Lorenzini, although considerably less sensitive).

Tyrrell, Taylor and Williams[4] suggest that the spontaneous discharge from the ampullæ is due to the existence of non-isothermal conditions. From experiments with *in situ* and isolated preparations, it can be stated that the discharge continues even when the whole preparation is at the same temperature; the same is true of the spontaneous discharge from the lateralis organs of *Xenopus*. Moreover, in both these sense organs the response to temperature

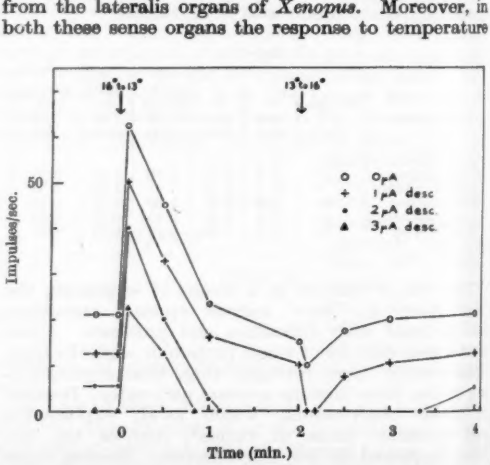

Fig. 1. Discharge frequencies in a single sensory unit from an ampulla of Lorenzini of *Raja clavata* showing the effect of a rise and fall of 3 deg. C. at four different current strengths (a descending current flows from sense organ to nerve, and an ascending from nerve to sense organ)

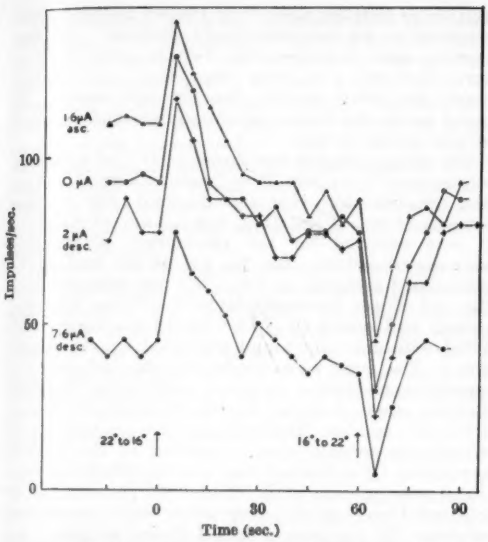

Fig. 2. Discharge frequencies in a multifibre preparation of lateralis organs of *Xenopus laevis* showing the effect of a rise and fall of 8 deg. C. at four different current strengths

change is the same irrespective of the direction of the spatial temperature gradient. They therefore agree in this respect with the cold receptors of the cat's tongue[5], and give no support to the spatial gradient theory of Lele, Weddell and Williams[6].

R. W. MURRAY

Department of Zoology and
Comparative Physiology,
University of Birmingham.
May 23.

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Long-term Transplants of Infantile Rat Pituitaries cultivated *in vitro* and grafted into the Anterior Eye Chamber of Young Cats

IN a previous communication in *Nature*[1], we have reported that successful grafts of the anterior rat pituitary have been obtained when glands cultivated *in vitro* were transplanted into the anterior eye chamber of very young cats. Following the same line of work, we have transplanted rat ovaries and testes, both normal and cultivated *in vitro*, under the kidney capsule of adult cats and observed a phenomenon which, so far as we know, has not been recorded in biological literature. A few days following the transplantation, at the site of grafting a 'tumour' was formed which when sectioned and stained was found to be composed almost exclusively of lymphocytes that had migrated into this region. Remnants of the grafted tissue, surrounded by lymphocytes, were also present, some in advanced stages of degeneration.

Further studies on the tumour tissue revealed a gradual process of organization suggesting lymphoid tissue normally scattered along the intestinal tract, with typical nodules composed of a central medulla and a peripheral cortex (Fig. 1). Some of these tumours of healthy tissue grew to the size of a pea. In some experiments as many as seven or eight nodules have been counted per section of the tumour tissue. The newly organized lympho-blastema persisted in the kidney long after the grafted tissue was destroyed (in the eye of the cat for four months and probably longer). If, however, cat ovaries or testes were transplanted under the kidney capsule of the rat, organized lymphoid tissue was not formed, although the number of transplants was not sufficient to warrant a definite conclusion. It appears that in the cat it is only living tissue that is capable of inducing the formation of organized lymphoid tissue at the site of transplantation, for spruce-wood splinters, knots of silk thread, boiled egg albumen and glass beads when placed under the kidney capsule, in repeated experiments, failed to produce this effect.

When the types of cells in the tissue found at the site of transplantation of some of the rat pituitaries in the eye of the cat were subjected to closer examination, it was found that they were comparable in every detail with the medullary portion of the lymphoid nodule developed at the site of transplantation of the rat gonad in the kidney of the cat. Hence we conclude that the graft-induced medullary portion of a lymph nodule in the eye of the cat was mistaken by us for the grafted pituitary tissue itself (Figs. 2 and 3 in our earlier communication).

We wish to make it clear, however, that we have definite evidence that some of the grafted explants of the rat pituitary survived for at least two months; the normal transplants did not survive (see Fig. 1 in the earlier communication). These persistent hetero-transplants, so far as we can tell, although intimately bound to the iris tissue of the host by fibrous connexions, were not vascularized, an observation which is in agreement with the findings of Merwin and Hill[2] on intraspecific grafts of normal tissue in mice. Further research has been undertaken in order to ascertain if non-vascularized hetero-transplants, similar to the homo-transplants reported by Merwin and Hill, survive for still longer periods.

Fig. 1. Two lymph nodules formed at the site of grafting of a piece of rat testis cultivated for 57 days and then implanted under the kidney capsule of a young cat; the nodules were fixed 53 days after the transplantation (iron hæmatoxylin; × 75)

In the face of evidence presented above, it is clear that our suggestion that embryo extract may have a protective action upon cultivated tissue following its transplantation into hosts belonging to a different species, will require further study, especially of the vascularized grafts. There is no doubt that the transplants previously cultivated *in vitro* behave differently from normal grafts; they establish circulation at a much later date than the latter, and, as a consequence, they survive longer.

P. N. Martinovitch
D. V. Radivojevitch

"Boris Kidritch" Institute for Nuclear Sciences,
Poštanski Fah 522,
Beograd, Yugoslavia.
July 8.

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Colicine *K*

Colicines are substances of unknown nature which are elaborated by certain strains of Enterobacteriaceae and which have the ability to kill other strains within this group. At the time of their discovery some thirty years ago[1], it was apparent that colicines bore a similarity to the bacteriophages, yet differed in that they could not be transmitted by serial passage. In recent years considerable attention has been paid these agents[2], largely because of this relationship and because of a renewed interest in the bacteriophages themselves. The brilliant investigations of Fredericq have revealed that there are many different colicines; some seventeen specific types have thus far been described[3]. Furthermore, these agents are now known to be elaborated by micro-organisms other than those of the enteric group. Because of this, the name 'bacteriocines' has been suggested to designate them[4].

The similarities between phages and colicines are striking. Thus, Fredericq[5] has demonstrated that colicine-susceptible micro-organisms yield resistant variants which are also resistant to certain phages, and vice versa. In addition, it has been shown that those chemical and physical agents which induce the release of phage from lysogenic bacilli can, in certain instances, also bring about liberation of colicine from colicinogenic micro-organisms[6]. Because of these seemingly intimate relationships, the implication has been made that colicines might be precursors of phages[7]. If this be true, one would expect these agents to bear some immunological relationship to one another. Yet it has not been possible to show, in the case of colicine *K*, that biological activity can be neutralized by an antiserum to the colidysentery phage *T6*, the virus to which this colicine is presumably related[8]. The affirmations which have appeared from time to time concerning the protein-like nature of colicines[1,9] are in reality not fully substantiated. These substances have never been isolated in purified form and hence their chemical status remains obscure.

Several years ago an attempt was initiated in this laboratory to isolate and characterize colicine *K*, to study its chemical and immunological properties and to relate these to phage *T6*. The following is an account of the present state of this investigation.

A strain of *E. coli* producing colicine *K* designated as *K*235 was kindly supplied by Dr. Pierre Fredericq. When these micro-organisms were plated on proteose-peptone or nutrient agar, they yielded colonies which appeared to be morphologically uniform. On neopeptone agar, however, two distinct colonial forms were observed; one was transparent and slightly rough, the other smooth, mucoid and opaque. In liquid media the latter elaborated five times as much colicine as the former.

The opaque variant was grown in 15 l. of a medium consisting of 1 per cent 'Difco' casamino-acids, 1·5 per cent glucose, 0·5 per cent dialysed 'Difco' yeast extract, 18 gm. of Na_2HPO_4 and 7·5 gm. of KH_2PO_4. It was essential for the production of maximal amounts of colicine that the *p*H of the medium be maintained precisely at 7·0. This was achieved with the aid of an electronic device[10]. When bacterial growth had ceased (2×10^{10} B/ml.) the bacilli were killed with chloroform and separated by centrifugation. The supernate containing the colicine was rapidly concentrated *in vacuo*, and, after thorough dialysis, crude colicine *K* was obtained by freeze-drying the residue. This material (5·0 gm.) contained several components when examined in the Tiselius apparatus. Purification was accomplished by fractional precipitation with ethanol (75 per cent) at 0° followed by repeated precipitation with ammonium sulphate (75 per cent) at *p*H 4·5, and dialysis. An aqueous solution of this material, which still contained two electrophoretically different components, was then shaken with chloroform-octyl alcohol. The colicine fraction formed an emulsion with the organic solvent which was separated by centrifugation. The inert fraction remained in the supernate. The colicine (1·0 gm.) was recovered from the chloroform emulsion by precipitation with ten volumes of ethanol at 0° C.

Purified colicine *K* obtained in this manner is water-soluble, colourless and free of nucleic acid. It contains 6·5 per cent of nitrogen and 1·6 per cent of phosphorus. In the Tiselius apparatus it appears to show but one electrophoretic component when examined at various *p*H values. In the ultracentrifuge, however, solutions are heterodispersed. The material appears to be a macromolecular substance constituted from carbohydrate, protein and lipid. It is toxic both in mice and rabbits and has potent antibacterial properties as well. 0·02 ml. of a solution containing 1·0 γ/ml., when placed on the surface of nutrient agar contained in a Petri dish and seeded with 5×10^7 *E. coli* b. cells, inhibits completely the growth of the bacilli encompassed by the area of the droplet. Colicine *K* is thermostable; its activity is unimpaired by heating a neutral aqueous solution for 10 minutes at 100° C. Such solutions are also stable at room temperature between *p*H 3·0 and 9·5. Activity is rapidly destroyed, however, by treating a solution at *p*H 8·0 with crystalline trypsin, or chymotrypsin, and by contact with 1 per cent formalin. Colicine *K* is a potent antigen. It elicits antibodies in rabbits which specifically precipitate the colicine, neutralize its antibacterial activity, and agglutinate the organisms from which the colicine was derived. In neutralization tests colicine *K* antisera do not cross-react with phage *T6*, however, nor do *T6* antisera precipitate or neutralize the colicine. Although *T6* resistant variants of Phase II *sh. Sonnei* exhibit resistance to colicine *K* and vice versa, this does not appear to be sufficient reason for believing that these two agents are otherwise related. The results of this study have revealed that phage *T6* and colicine *K* have neither chemical nor immunological properties in common.

The chemical, physical, immunological and toxic properties of the substance obtained from the culture medium in which *E. coli K235* is grown indicate that the material having colicine *K* activity is the somatic or *O* antigen of the bacillus. The fact that this complex has potent antibiotic properties seems at first sight extraordinary. Yet it should not be forgotten that *O* antigens of Gram-negative bacilli exert potent toxic effects upon certain mammalian species. It is not inconceivable, therefore, that they might exert a similar effect upon an occasional bacterial species.

It cannot yet be said with complete certainty, however, that colicine activity is an inherent property of the *O* antigen of *E. coli K235*. It is possible that colicine *K* is in reality a distinct molecular species bound to the lipocarbohydrate protein complex. If this is the case, the union is firm, and has until now defied attempts at dissociation. From the evidence at hand, however, we are at the moment inclined to favour the first point of view.

Walther F. Goebel
Guy T. Barry
Margeris A. Jesaitis
Elizabeth M. Miller

Rockefeller Institute for Medical Research,
New York.
May 23.

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Anti-acetylcholine and Anti-histamine Actions of the Total Alkaloids of *Rauwolfia serpentina* Benth

Dasgupta, Ray, Roy and Werner[1], Mukherjee[2] and the present authors[3] have made certain observations on the anti-adrenaline effect of extracts of *Rauwolfia serpentina*, but their effects on the action of acetylcholine or of histamine have not yet been reported. Experiments have been carried out on isolated strips of guinea pig ileum in Dale's bath, containing oxygenated Ringer–Locke's solution at 35° C., and the modifications caused by varying concentrations (10^{-6} to 10^{-4} gm./ml.) of extracts of *Rauwolfia serpentina* (total alkaloids extracted in 2 per cent hydrochloric acid) on the action of acetylcholine (10^{-8} gm./ml.) or of histamine (10^{-8} to 10^{-7} gm./ml.) were studied. The extracts produced, by themselves, a definite but slight and transient contraction of the intestine. Dasgupta *et al.*[1] did not, however, find any stimulating effect on intestine *in situ*, whereas Chopra, Gupta and Mukherjee[4] mention a stimulating property of the extract on such a preparation. (Dr. R. P. Banerjee, of the Indian Council for Medical Research, prepared extracts of *Rauwolfia serpentina* in three different concentrations of hydrochloric acid (namely, 2, 5 and 10 per cent) with the view of fractionating the different active principles. The results obtained with an extract in 2 per cent hydrochloric acid are described here; those with 5 and 10 per cent acid extracts are under investigation.)

Anti-acetylcholine action. In all of the twelve experiments carried out, there was a greater degree of inhibition of the action of acetylcholine in the presence of the higher concentration of the extract of *Rauwolfia* in the bath, when the former was applied 30–50 sec. after the administration of the extract to the bath fluid. A concentration of the extract of 5×10^{-5} gm./ml. and stronger completely annulled the effect of 10^{-8} gm./ml. acetylcholine.

Anti-histaminic action. The results with histamine applied 30–50 sec. after *Rauwolfia* extract were similar to those with acetylcholine mentioned above. The extract of *Rauwolfia* in concentrations of 5×10^{-5} gm./ml. and stronger inhibited the action of histamine (10^{-8} or 5×10^{-8} gm./ml.). A stage of slight potentiation of the action of both acetylcholine and histamine was noted in a few cases during the phase of recovery of the action of acetylcholine and histamine on repeated changing of the bath fluid, after an earlier observation of the action in the presence of *Rauwolfia* extract.

M. L. Chatterjee
H. F. Häusler

Department of Pharmacology,
School of Tropical Medicine,
Calcutta.

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'Kernechtrot' or Nuclear Fast Red in the Histochemical Detection of Calcareous Corpuscles in *Taenia saginata*

Taenia saginata, like many other cestodes[1], is known to contain numerous calcareous corpuscles or calcium balls distributed throughout the parenchyma. These corpuscles, in addition to their calcium content, consist of an organic base, containing[2] deoxyribo- and ribo-nucleic acids, simple proteins, glycogen and a hyaluronic acid-type of polysaccharide. With Gomori's modified technique these corpuscles also gave a positive reaction for alkaline phosphatase. The presence of calcium in these balls was indicated by von Kossa's silver test for calcium[3].

McGee-Russell[4] has recently reported the selective affinity of 'Kernechtrot' or nuclear fast red (batch 3569) for soluble inorganic calcium salts and its use in the histochemical detection of calcium.

We have tried to confirm the specificity of this dye by using the proglottids of *T. saginata* with their calcium-containing corpuscles as test material. It has been observed that the dye stains these corpuscles, and in some cases their immediate neighbourhood, brilliant red (see Fig. 1). As an experimental control we have stained in a similar manner identical sections of the same tissues after previous treatment with citrate buffer (*p*H 4·5–5) to remove calcium. The corpuscles failed to take up the dye in this case. This observation therefore confirms the conclusion regarding specificity of the dye for detecting calcium in the tissues. A detailed account of this work will be published elsewhere.

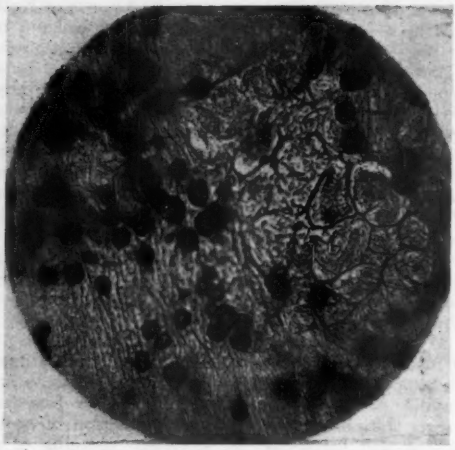

Fig. 1. Photomicrograph of part of a section of a proglottid of *Taenia saginata* showing the calcareous corpuscles stained with nuclear fast red. × 160

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A. B. Chowdhury
B. Dasgupta
H. N. Ray

School of Tropical Medicine,
Calcutta. May 24.

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Inhibition Steps in Sulphonamide Bacteriostasis

The activity of several compounds, structurally unrelated to *p*-aminobenzoic acid, in reversing growth inhibition of *Escherichia coli* by sulphonamides, was explained by Shive and Roberts[1] as due to their being products of enzymes associated with *p*-aminobenzoic acid. Using increasing concentrations of sulphanilamide, these authors showed that it inhibits sequentially the synthesis of methionine and xanthine by the organism. Winkler and de Haan[2] extended this study to higher concentrations of the inhibitor, and reported further involvement of serine and thymine (the latter, interchangeably with pteroyl glutamic acid) in that order in the *p*-aminobenzoic acid action; further addition of valine was stimulatory to growth.

During studies on the reversal of growth inhibition of *Esch. coli* (McLeod) by sulphadiazine, we observed that, in a concentration of the drug up to 30 mgm. per cent, a combination of the foregoing five metabolites was necessary and effective; however, at its maximum solubility (50 mgm. per cent) in the medium employed[3] they could no longer overcome growth inhibition. When, in addition to them, mixtures of purines and pyrimidines, amino-acids, or the *B*-group of vitamins were tried (see Table 1), it was found that the amino-acid mixture, and to a less extent the vitamins, could reverse considerably the inhibition of growth by the drug. Using individual amino-acids,

Table 1. Reversal Effects on Growth Inhibition of *Esch. coli* by Sulphadiazine

	Additions to 10 c.c. of basal medium[a]	Growth[b] without sulphadiazine	Growth[b] with sulphadiazine (5 mgm./10 c.c.)
1	None	47	0
2	*p*-Aminobenzoic acid (0·5 mgm.)	47	46
3	Methionine (0·5 mgm.) + xanthine (0·25 mgm.) + serine (0·2 mgm.) + thymine (0·25 mgm.) + valine (0·5 mgm.)	49	0
4	As in (3) + amino-acid mixture[c]	72	53
5	As in (3) + vitamin mixture[d]	46	25
6	As in (3) + purine–pyrimidine mixture[e]	48	0
7	As in (3) + glycine (0·25 mgm.)	48	27
8	As in (3) + threonine (0·4 mgm.)	47	19
9	As in (7) + threonine (0·4 mgm.)	48	28
10	As in (3) + vitamin B_{12} (10 mμgm.)	49	23
11	As in (7) + vitamin B_{12} (10 mμgm.)	47	40
12	As in (11), but with 0·1 mgm. each of adenine, xanthine and guanine in place of 0·25 mgm. of xanthine	50	48

[a] Green and Sevag (ref. 3).
[b] Represents 48 hr. growth in terms of turbidity measured on a Klett-Summerson photocolorimeter at 660 mμ.
[c] 0·2 mgm. each of alanine, arginine, asparagine, aspartic acid, cysteine, glutamic acid, glycine, histidine, isoleucine, leucine, lysine phenyl alanine, proline, threonine, tryptophan and tyrosine. In all experiments, racemic forms of the optically active amino-acids were used.
[d] Thiamine hydrochloride, riboflavin, nicotinic acid, pantothenic acid, and pyridoxine hydrochloride (10 μgm. each), pteroyl glutamic acid (3 μgm.), 'Leucovorin', Lederle (3 μgm.) and vitamin B_{12} (10 mμgm.).
[e] 0·1 mgm. each of adenine, guanine and uracil.

it was ascertained that the active member was either glycine or threonine; the former was more effective than the latter on a molar basis, and there was no additive effect among the two. Vitamin B_{12} alone, among the B vitamins, showed a reversal effect. A combination of glycine and vitamin B_{12} was nearly as active as *p*-aminobenzoic acid, and substitution of xanthine by a mixture of purines (xanthine, adenine and guanine) gave reversal of growth inhibition comparable to that with *p*-aminobenzoic acid (Table 1).

It would seem from the above that synthesis of glycine is yet another reaction mediated by *p*-aminobenzoic acid and blocked by sulphonamides. The organism *Esch. coli* is apparently capable of converting threonine to glycine (cf. ref. 4). Such a possibility is also indicated from the observation of Ravel *et al.*[5] that glycine and threonine both increase synthesis of 4-amino-5-imidazole carboxamide by *Esch. coli* under conditions of sulphonamide bacteriostasis.

It is difficult to explain the relationship observed here between the action of *p*-aminobenzoic acid and that of vitamin B_{12} solely on the basis of an effect of the former on the synthesis of the latter[6]. Shive[6,7] had also reported on the potentiating action of vitamin B_{12} on methionine, xanthine and serine, at each stage in their reversal of sulphanilamide action, and on the replaceability of thymine by pteroyl glutamic acid or by vitamin B_{12}.

H. R. Alimchandani
A. Sreenivasan

Department of Chemical Technology,
University of Bombay. May 4.

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Density Inversions in Canadian Eastern Arctic Waters

Among the hydrographic results of the *Calanus* expeditions of 1949–51 in Ungava Bay, Hudson Strait and Frobisher Bay, sponsored by the Fisheries Research Board of Canada, are twenty-two instances of density inversion showing unstable conditions in the sea. They were observed at twenty stations (two stations showing inversion at two different depths) out of a total of forty-eight stations occupied during the three seasons. Six of the inversion stations were in Ungava Bay, one in the Button Islands north of Cape Chidley, four in Hudson Strait between Wakeham Bay and Lake Harbour, and the remainder in Frobisher Bay.

Such instabilities, appearing in oceanographic results in the past, have usually been looked upon as fictitious, and attributed to errors in thermometer readings, sample labelling, titration or filing of results. In the present instance, titrations have been repeated where possible, and the methods used on board ship seem to preclude the possibility of other errors. Recently, Spilhaus *et al.*[1] have recorded similar inversions in the waters just south of Cape Cod, and have given evidence of some correlation of the times of observed instability with the times of lunar transit. I am informed by Dr. Carsola (personal communication) that inversions of short duration are common in shallow-water observations in progress at the U.S. Navy Electronics Laboratory at San Diego, and Dr. John Tait, of Aberdeen, has reported (at the 1952 meeting of the *Conseil Permanent* in Copenhagen) some more or less persistent instabilities observed during work in the Faero-Shetland Channel. There is a published record of another example, in the Okhotsk Sea, from the nineteenth century[2], and the *Michael Sars* expedition of 1910 found a density inversion at one station in the Atlantic (28° 37′ N.; 19° 08′ W.)[3].

The *Calanus* observations have been related to the state of the tide in each instance and are plotted on a tidal clock in Fig. 1. Tests (χ^2) comparing the radial scatter of the stations with inversions, those without, and of all stations, respectively, with an equally distributed radial pattern, give the P values shown. The latter two observed distributions are reasonably close to a random scatter, as would be expected; but the distribution of the instabilities verges on disagreement with random scatter, and the P value for the comparison of the means (standard error of the difference of the means) of the inversion and non-inversion stations is on the margin of significant disassociation (difference is 2·02 times its standard error). It is, moreover, at once apparent on examination that, of the twenty inversion stations, half lie in one quadrant, in the first three hours of the ebb tide.

Fig. 1. A twelve ½-hour tidal clock, showing the times, with respect to tide, at which stations with density inversions (black circles) and without density inversions (open circles) were occupied. The P values are explained in the text: ●, $P = 0{\cdot}065$; ○, $P = 0{\cdot}345$; ● + ○, $P = 0{\cdot}565$; *S.E.*$_d$, $P = 0{\cdot}055$

The establishment of these unstable conditions, even for the short periods of time during which they probably exist, obviously requires considerable forces, which are apparently to be found in the extreme tidal movements of the area. Hudson Strait tides are very high (33 ft. at Ashe Inlet), the mean spring tide interval at Frobisher Bay is 32½ ft., and a tide of more than 50 ft. has recently been recorded at the head of Ungava Bay.

The details of this work will appear in full in due course.

M. J. Dunbar

Eastern Arctic Investigations,
Fisheries Research Board of Canada, and
Department of Zoology, McGill University,
Montreal. April 6.

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Temperature-Ranges and Distributions of some Vascular Plants

Attempts to fit isotherms to certain limits of areas of plant distributions have sometimes been successful; but, for example, in the discussion of the areas given in the Biological Flora of the British Isles, only rarely is an isotherm limit shown. A July isotherm is given as an upper temperature limit for *Lobelia dortmanna*[1], and a July or August isotherm as a lower limit for *Halimione portulacoides*[2], and a January isotherm as a lower limit for *Arbutus unedo*[3]; and in addition to these and some other examples in the literature, I notice that the January (actual) isotherm 35° F. gives an approximate fit for the southern limit[4] of *Andromeda polifolia*. The fact of a broad coincidence between an isotherm and a limit of a distribution does not prove a relationship, but nevertheless a reasonable fit has usually been taken as indicating that temperature may probably be the limiting factor.

A limit of winter cold will obviously operate on a plant in a different way from a limit of July heat; and four possible sorts of temperature limits have been quoted above for particular cases. It could be supposed that for each plant species there may be, in broad terms, an optimum summer temperature, with upper and lower limits (beyond which the species is either damaged or else is at a disadvantage in competition with other species better adapted to the particular temperature-levels), and an optimum winter temperature, with upper and lower limits. Winter limits might be expected to operate most typically at the month of lowest temperature (as an approximation, January in the northern hemisphere); and although July might not always be the most operative summer month, in long-term means, deviations of adjacent months would at least be approximate functions of July deviations.

It does not, however, seem to have been generally realized how frequently plant areas can be represented

by a combination of upper and lower limits respectively both for January and July (with January and July limits transposed for the southern hemisphere). The envelopes of the distributions I have used in Figs. 1 and 2 are of the same form as that referred to in a recent communication[5] as governing the world distribution of acarine disease of bees, and the general formula for the envelope is:

$$(\gamma_2 - \gamma_1)^2(2\alpha - \alpha_1 - \alpha_2)^2 + (\alpha_2 - \alpha_1)^2(2\gamma - \gamma_1 - \gamma_2)^2 = (\gamma_2 - \gamma_1)^2(\alpha_2 - \alpha_1)^2$$

where α, α_1, α_2 are respectively January actual temperature and lower and upper limits of the temperature, and γ, γ_1, γ_2 are July actual temperature and lower and upper limits.

Forty-one distributions have so far been plotted, including the twenty areas given in Prof. J. R. Matthews's recent book[4], seven from the Biological Flora of the British Isles[6], and fourteen from other sources, reproduced by Cain[7] and Zander[8]. In this material, thirty gave really useful approximations to the given distributions, whereas in ten there were discrepancies which seemed of greater importance, and in one (*Lloydia serotina*) the fit was not satisfactory with the approximate and not very detailed isotherms which have so far been used. This is possibly due to the fact that these isotherms may not accurately represent the temperatures of the mostly isolated mountain sites where this species is found. There have been indications that the difficulty may be rather general with such species. Some of the other anomalies so far encountered seem to be partly explainable in terms of major rainfall differences between different parts of the areas.

Fig. 1. *Ilex aquifolium.* ———, Distribution from Matthews, ref. 4, p. 128 (after Oltmanns); · · · · · · , approximate curve for $\alpha_1 = 30°$ F., $\alpha_2 = 44°$ F., $\gamma_1 = 54^5$ F., $\gamma_2 = 86°$ F.

Fig. 2. *Ranunculus lenormandi.* ———, Distribution from Matthews, ref. 4, p. 130 (after Salisbury); · · · · · · , approximate curve for $\alpha_1 = 38°$ F., $\alpha_2 = 48°$ F., $\gamma_1 = 58°$ F., $\gamma_2 = 68°$ F.
Picea excelsa. ———·———, Distribution from Zander, ref. 8, p. 41 (after Hueck); – – – – –, approximate curve for $\alpha_1 = 2°$ F., $\alpha_2 = 30°$ F., $\gamma_1 = 52°$ F., $\gamma_2 = 60°$ F.

The more accurate plotting of these areas is now in hand, and further maps will in due course be published elsewhere.

It may be noted that this distribution is closely similar to, and in certain cases identical with, that obtained by a formula of the same form embodying a range of annual mean temperature and a range of January–July temperature differences. It can also be shown that, for the world as a whole, annual temperature-range is an approximate function of the annual precipitation (P), and if there had been an exact relationship between these quantities it would have followed that similar areas could have been obtained by a formula of the same sort embodying a range of annual mean temperature and a range of the function of P. This would have corresponded approximately with the usually accepted idea of temperature bands modified by different levels of humidity. Interesting and sometimes useful areas can be obtained in this way, but they have not generally proved so close as those obtained from temperatures alone.

I wish to thank Prof. J. R. Matthews for his interest in this work, and Dr. G. D. Morison and Prof. V. C. Wynne-Edwards for help in connexion with the literature, also Dr. D. J. Finney for mathematical advice.

E. P. Jeffree

Bee Research Department,
North of Scotland College of Agriculture,
and Botany Department,
University of Aberdeen. May 23.

[3] Woodhead, N., *J. Ecol.*, **39**, 460 (1951).
[4] Chapman, V. J., *J. Ecol.*, **38**, 214 (1950).
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[8] Zander, E., in "Studien zur Herkunftsbestimmung bei Waldhölzgen", 41 (1949), after Hueck, K.

Effect of Indian Ink on *Plasmodium berghei* Infections in Mice

INJECTIONS of indian ink, causing so-called 'blockade' of the reticulo-endothelial system, have, in the past, been classified with splenectomy and cortisone as agents calculated to lower the resistance of host animals to plasmodial infections. For example, Trager[1], working with chickens infected with *Plasmodium lophurae*, found that indian ink usually caused the development of heavy parasitæmias in the birds receiving it.

Recently, I have found[2] that cortisone does not produce higher parasitæmias in mice or hamsters infected with *P. berghei*, and this has been confirmed by Singer, who has also shown that this is equally true of splenectomy[3]. I have now found that indian ink has a strongly inhibitory effect on infections with this *Plasmodium*.

Mice were injected intraperitoneally with 0·2 ml. of a commercial indian ink, diluted with the same amount of physiological saline. This large dose was well tolerated, and was followed next day by intraperitoneal inoculation with infected citrated hamster blood. A similar number of control mice received saline followed by infected blood. Blood films were made daily and were stained with Giemsa.

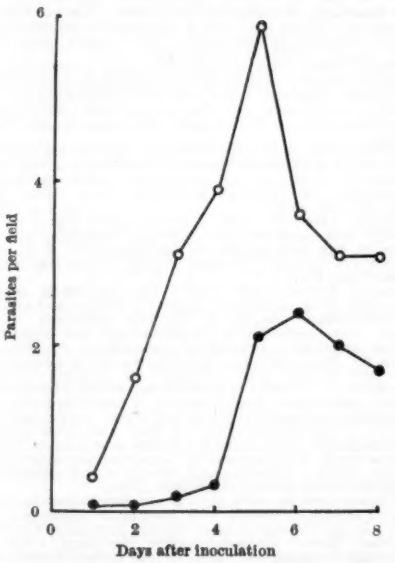

Fig. 1. Parasitæmia in mice treated with indian ink and infected with *P. berghei*. O—O—, Average of five control mice; ●—●—, infection in one mouse, Af 35, treated with indian ink

Of five mice treated with indian ink, one died on the day following infection, and of the others, three showed only occasional parasites throughout the eight days that the experiment lasted, while the fifth mouse had a very low parasitæmia. The infection proceeded normally in the control mice. For two or three days after the ink injections there were many polymorphonuclear leucocytes in the peripheral blood, but these soon fell to a normal level. Seven or eight days after infection, the experimental animals showed a considerable degree of anæmia, with greatly increased numbers of reticulocytes in the peripheral blood, but parasites were very rare.

Indian ink greatly stimulated the production of immature red cells, apart from its effect on the macrophages. In this experiment, the one mouse that had a low-grade parasitæmia had many reticulocytes in the peripheral blood—supposedly the preferred substrate for parasite growth—after several days, yet no great increase in parasitæmia occurred. Further investigations are needed before any definite conclusions can be drawn.

O. J. ROBERTS LOXLEY

Ross Institute of Tropical Hygiene,
London School of Hygiene and Tropical Medicine,
London, W.C.1.
May 20.

[1] Trager, W., *Amer. J. Hyg.*, **34**, 141 (1941).
[2] Roberts, O. J., *Parasit.*, **44**, 58 (1954).
[3] Singer, I., *J. Inf. Dis.*, **94**, 159 and 164 (1954).

An Uncollected Record of the Great Sea-serpent

COMPILATIONS and bibliographies are double-edged weapons; though they facilitate access to some sources of information, they usually tend to intensify the concealment of others. Some two hundred reports of the sea-serpent have been collected and analysed in the works of Oudemans[1] and of Gould[2]; but the record which follows has so far escaped scientific notice. Though trivial by itself, it corroborates a number of more detailed accounts of a similar monster in the North Atlantic towards the end of the eighteenth century.

Thomas Holcroft[3] (1745–1809), in a letter written in 1799, describes an interview on board the *Kennet* (Captain Thompson). After recounting two second-hand stories of the Kraken and comparing these with Pontoppidan's versions, Holcroft continues:

"Finding this Leviathan so familiar to their belief, I next inquired if they had heard, or knew any thing of the sea-snake, by some called the sea-worm? To this question I received a still more direct answer. The Mate, Mr. Baird, who certainly was not a liar by habit, whatever mistake or credulity might make him, assured me that, about midway in a voyage to America, in the Atlantic, he had himself seen a fish, comparatively small in the body, of from forty to fifty fathoms in length; and that it had excited great terror in the Captain, who was well acquainted with those latitudes, lest it should sink the ship.

". . . and I think it a duty to collect evidence, and to remain on this question, as on many another, in a certain degree of scepticism."

DENYS W. TUCKER

British Museum (Natural History),
London, S.W.7.
June 1.

[1] Oudemans, A. C., "The Great Sea-Serpent" (Leyden and London, 1892).
[2] Gould, R. T., "The Case for the Sea-Serpent" (London, 1930); "The Loch Ness Monster" (London, 1934).
[3] Hazlitt, W., "Memoirs of the late Thomas Holcroft" (London, 1816). (The present extract taken from "The Complete Works of William Hazlitt", edit. P. P. Howe, **3**, 252 (Dent, London, 1932).)

FORTHCOMING EVENTS

*(Meetings marked with an asterisk * are open to the public)*

Monday, October 10

KING'S COLLEGE, LONDON (at King's College, Strand, London, W.C.2), at 5.30 p.m.—Mr. Gabriel Kron: "Tensor Analysis of Rotating Electrical Machinery". (Further Lectures on October 11, 12, 13 and 14.)

UNIVERSITY OF LONDON (in the Gustave Tuck Theatre, University College, Gower Street, London, W.C.1), at 5.30 p.m.—Dr. F. Safar (Baghdad): "Hatra—the City and its Inscriptions". (Further Lectures on October 12 and 14.)*

UNIVERSITY COLLEGE, LONDON (in the Physiology Theatre, Gower Street, London, W.C.1), at 5.30 p.m.—Prof. J. F. Danielli: "Physico-Chemical Mechanisms of Drug Action".*

UNIVERSITY OF LONDON (in the Geology Lecture Theatre, Imperial College of Science and Technology, London, S.W.7), at 5.30 p.m.—Prof. B. Gutenberg (U.S.A.): "Low Velocity Layers". (Further Lecture on October 14.)*

Tuesday, October 11

ZOOLOGICAL SOCIETY OF LONDON (in the Mappin Refreshment Pavilion, Mappin Terrace, Zoological Gardens, Regent's Park, London, N.W.1), at 5 p.m.—Scientific Papers.

UNIVERSITY OF LONDON (in the Hall of the Royal Geographical Society, Kensington Gore, London, S.W.7), at 5.30 p.m.—Dr. R. P. Linstead: "The Future of the Imperial College".

SOCIETY OF CHEMICAL INDUSTRY, PLASTICS AND POLYMER GROUP (in the Rooms of the Chemical Society, Burlington House, Piccadilly, London, W.1), at 6.30 p.m.—Discussion on "Physical Properties and Testing of Polymers".

UNIVERSITY OF LONDON (at the Institute of Archæology, Inner Circle, Regent's Park, London, N.W.1), at 8.15 p.m.—Prof. V. G. Childe: "The Culture Sequence in Prehistoric Thrace". (First of two Lectures on "New Archæological Discoveries in Bulgaria". Further Lecture on October 18.)*

Wednesday, October 12

UNIVERSITY OF LONDON, SCHOOL OF PHARMACY (in the Beveridge Hall, Senate House, London, W.C.1), at 3 p.m.—Sir Ian Heilbron, F.R.S.: "The Chemist and Pharmacist on a Common Front" (Inaugural Address at the Opening of the 114th Session of the School of Pharmacy).

GEOLOGICAL SOCIETY OF LONDON (at Burlington House, Piccadilly, London, W.1), at 5 p.m.—Prof. Beno Gutenberg (U.S.A.): "The Energy of Earthquakes" (Eleventh William Smith Lecture).

SOCIETY OF CHEMICAL INDUSTRY, CORROSION GROUP (at the Chemical Society, Burlington House, Piccadilly, London, W.1), at 6.30 p.m.—Mr. F. A. Champion and Mr. G. W. Walkiden: "The Composition of Sprayed Aluminium Coatings"; Mr. T. P. Hoar: "Sprayed Alloy Coatings".

SOCIETY OF CHEMICAL INDUSTRY, FOOD GROUP (at the Linnean Society, Burlington House, Piccadilly, London, W.1), at 6.30 p.m.—Meeting on "Factors Affecting the Choice of Food".

Wednesday, October 12—Friday, October 14

IRON AND STEEL INSTITUTE (at Scunthorpe)—Special Meeting.

Thursday, October 13

UNIVERSITY COLLEGE, LONDON (in the Anatomy Theatre, Gower Street, London, W.C.1), at 1.15 p.m.—Dr. J. G. Capewell: "Some Episodes in the Geological History of the Lake District".*

UNIVERSITY COLLEGE, LONDON (in the Physiology Theatre, Gower Street, London, W.C.1), at 5 p.m.—Dr. J. Monod (Paris): "Specific Factors in the Biosynthesis of Enzymes".*

UNIVERSITY OF LONDON (at Goldsmiths' College, Lewisham Way, London, S.E.14), at 5 p.m.—Prof. Sir Cyril Burt: "The Delinquent Child". (First of six Lectures on "Psychology and Education". Further Lectures on October 20, 27, November 3, 10 and 17.)*

UNIVERSITY COLLEGE, LONDON (in the Anatomy Theatre, Gower Street, London, W.C.1), at 5.30 p.m.—Dr. J. Eric S. Thompson (Carnegie Institution of Washington): "The Rise and Fall of Maya Civilization". (First of three Special University Lectures in Anthropology. Further Lectures on October 14 and 17.)*

UNIVERSITY OF LONDON (at Queen Elizabeth College, Campden Hill Road, London, W.8), at 5.30 p.m.—Sir Russell Brain: "Dr. Johnson and Science".

COLLEGE OF PRECEPTORS (in association with the School Nature Study Union at 2 Bloomsbury Square, London, W.C.1), at 6 p.m.—Mr. E. E. Syms and Mr. A. Brownlee: "The Keeping of Animals for Observation".

Friday, October 14

TEXTILE INSTITUTE (at 10 Blackfriars Street, Manchester 3)—Mr. J. R. Whinfield: "Textiles and the Inventive Spirit" (Fifth Emsley Lecture).

BRITISH MYCOLOGICAL SOCIETY (in the Physics Lecture Theatre, Birkbeck College, Malet Street, London, W.C.1), at 11 a.m.—Meeting on "Diseases of Fruit and Hops".

SOCIETY OF CHEMICAL INDUSTRY, MICROBIOLOGY GROUP (at the National College of Food Technology, Cranwood Street, London, E.C.1), at 4 p.m.—Demonstration Meeting—"Some of the More Recent Techniques and Apparatus used in Microbiology".

NORTH EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS (in the Lecture Theatre of the Literary and Philosophical Society, Newcastle-upon-Tyne), at 6.15 p.m.—Commander J. R. H. Bull, R.N.: "Impact of the Development of Atomic and Thermonuclear Weapons on the Royal Navy".

Saturday, October 15

ASSOCIATION OF SCHOOL NATURAL HISTORY SOCIETIES (in the Lecture Hall, British Museum (Natural History), Cromwell Road, London, S.W.7), at 11 a.m.—Annual Exhibition.*

BRITISH PSYCHOLOGICAL SOCIETY (in the Gustave Tuck Theatre, University College, Gower Street, London, W.C.1), at 2.30 p.m.—Prof. J. S. Bruner (Harvard University): "Strategies in Thinking".

APPOINTMENTS VACANT

APPLICATIONS are invited for the following appointments on or before the dates mentioned:

SENIOR LECTURER (graduate) IN THE DEPARTMENT OF MATHEMATICS—Registrar, College of Technology and Commerce, The Newarke, Leicester (October 12).

LECTURER IN ANATOMY—The Warden and Secretary, Royal Free Hospital School of Medicine, 8 Hunter Street, London, W.C.1 (October 14).

ASSISTANT EXPERIMENTAL OFFICER (with a pass degree or at least general certificate of education (advanced level) IN THE PLANT PATHOLOGY SECTION—The Secretary, National Vegetable Research Station, Wellesbourne, Warwick (October 17).

SENIOR LECTURER (or LECTURER) IN MATHEMATICS—The Clerk to the Governors, Chelsea Polytechnic, Manresa Road, London, S.W.3 (October 19).

HEAD OF THE MECHANICAL ENGINEERING DEPARTMENT; HEAD OF THE ELECTRICAL ENGINEERING DEPARTMENT; HEAD OF THE PHYSICS DEPARTMENT; SENIOR LECTURER IN MECHANICAL ENGINEERING; and a SENIOR LECTURER IN CHEMISTRY—The Principal, College of Technology, Belfast, N. Ireland (October 21).

ASSISTANT BIOCHEMIST (basic grade) (with a B.Sc. degree with honours in chemistry or biochemistry, or an equivalent qualification)—The Group Secretary, Royal Hospital, Wolverhampton.

ASSISTANT (preferably with some special knowledge of histology) IN THE DEPARTMENT OF PHYSIOLOGY—The Secretary, The University, Edinburgh.

LECTURER (with an honours degree in electrical engineering or in physics (and/or a Chartered Electrical Engineer) and with industrial experience in electronics or telecommunications) IN ELECTRICAL ENGINEERING—The Principal, North-West Kent College of Technology, Dartford, Kent.

RESEARCH ASSISTANT (with a good honours degree in geology, preferably with emphasis on mineralogy, petrology, or structural geology) IN THE DEPARTMENT OF GEOLOGY—Prof. J. C. Brindley, Department of Geology, University College, Science Buildings, Upper Merrion Street, Dublin.

RESEARCH ENTOMOLOGIST, Senior Scientific Officer or Scientific Officer grade (with an honours degree in biology and at least two years postgraduate training or approved experience in scientific research, with specialization in entomology and preferably with statistical training or interest in statistics) at the West African Institute for Trypanosomiasis Research, for duties primarily in connexion with research upon the behaviour, breeding and longevity of the tsetse fly—Director of Recruitment, Colonial Office, Sanctuary Buildings, Great Smith Street, London, S.W.1, quoting BCD.197/198/04.

SCIENTIFIC ASSISTANT (with a science degree, a good reading knowledge of two European languages (of which one should preferably be other than French or German) and ability to write good English) for work in scientific information service involving abstracting and indexing—The Director, Commonwealth Bureau of Soil Science, Rothamsted Experimental Station, Harpenden, Herts.

SCIENTIFIC OFFICER (with first- or second-class honours degree in biological science, preferably with training or experience in microbiology), to assist in studies on alimentary microflora of farm animals—Secretary, Rowett Research Institute, Bucksburn, Aberdeenshire.

SCIENTIFIC OFFICER (with first- or second-class honours degree in mathematics, physics or electrical engineering or equivalent qualification) for the Air Ministry in London, Maidenhead, Berkshire and Norfolk, for operational research duties, theoretical studies and development work in the field of communications and general electronics—The Ministry of Labour and National Service, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting A.113/5A.

SCIENTIFIC OFFICERS (with first- or second-class honours degree in mathematics or physical sciences or equivalent qualification) at the National Physical Laboratory, Teddington, for work in physics (including radiology), mathematics and electric computers (Ref. A.338/5A), and metallurgical chemistry (Ref. F.449/5A)—The Ministry of Labour and National Service, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting appropriate Ref. No.

SENIOR ENTOMOLOGIST AT THE GLASSHOUSE CROPS RESEARCH INSTITUTE—The Secretary, Glasshouse Crops Research Institute, Rustington, Littlehampton, Sussex.

SENIOR EXPERIMENTAL OFFICER (with G.C.E., advanced level in science subjects, or equivalent qualifications) to take charge of the Technical Records Section at Dounreay Works, Caithness—The Recruitment Officer, United Kingdom Atomic Energy Authority, Industrial Group Headquarters, Risley, near Warrington, Lancashire, quoting 1113.